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JUNE

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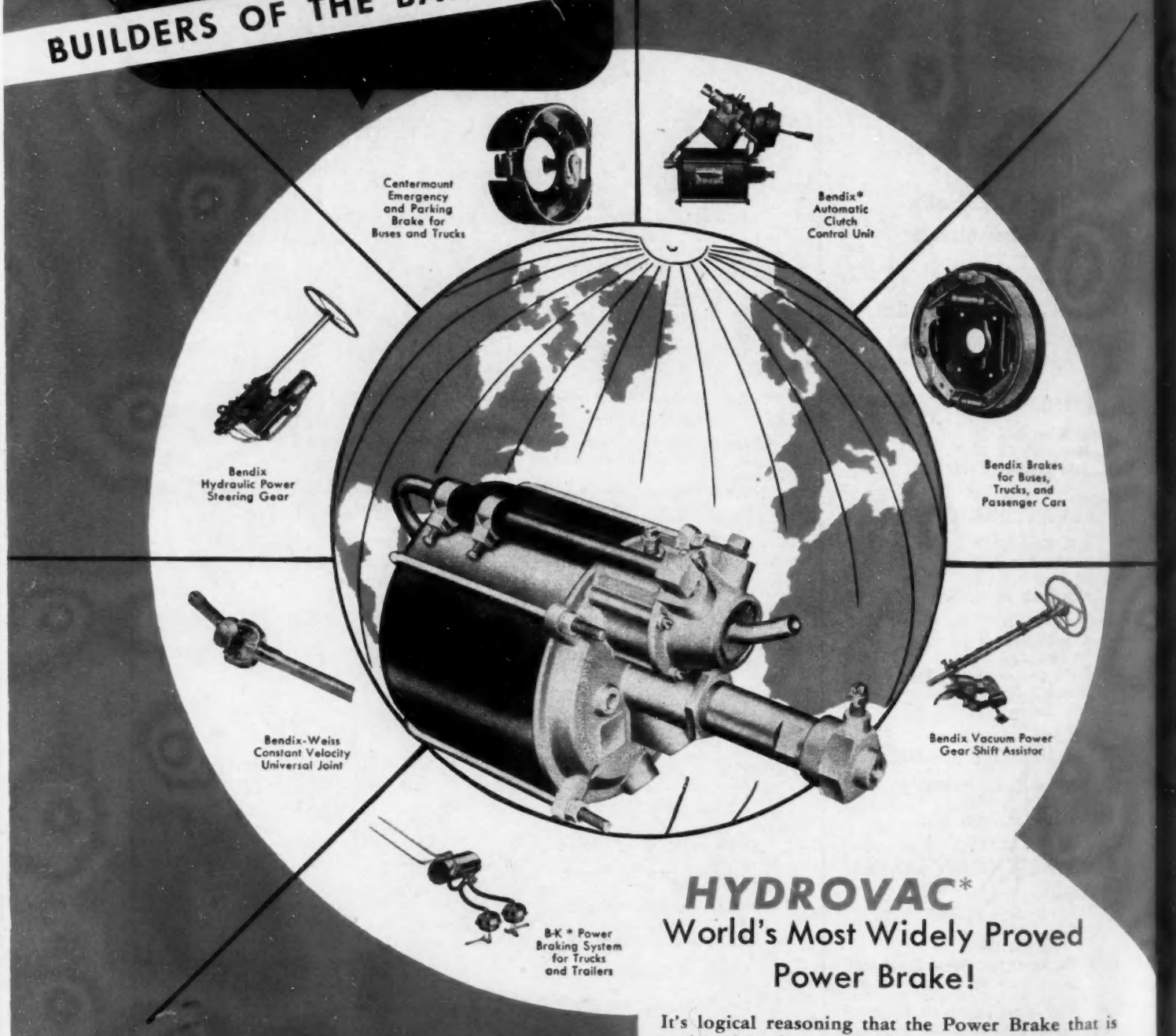
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DESIGN CARS FOR POOR DRIVERS

Is Suggested by Highway Official

EXCERPTS FROM PAPER* BY **Maxwell Halsey**

Executive Secretary,
Michigan State Safety Commission

THE present car coming off the production line is a relatively safe vehicle. It's certainly safe enough so that really good drivers can drive hundreds of thousands of miles without an accident. But it's not as good as it could be in compensating for errors of poor drivers.

Brakes are a lot better than they were a few years ago. Headlights are much more effective. Steering is a good deal safer. Visibility has improved some. And car structures protect the motorist much more than they used to.

But drivers still make mistakes that might be cured by design and never may be cured completely through safety education. Driving conditions are much more dangerous than they used to be. They put far greater strain on safe-driving ability of the average motorist than ever before.

Let's assume that since Adam and Eve the human being always made mistakes; and despite all that safety education, driver training, enforcement, driver license control, and better roadway design can do, some people will still make mistakes.

Let us take the position, for example, that even though the motorist was driving 10 mph faster than he should, he would be alive today if he could have seen a little easier, if his brakes had stopped the car a little quicker. If the engineer can tell himself, "one motorist is alive today, despite his error in judgment, because of an engineering improvement I made," it would be a real contribution.

And there is much the automotive engineer can do to make the car safer. . . improved vision, better braking, and revised conceptions of the speedometer's job are just a few items along this line.

BETTER VISION

Any motorist knows his chances of avoiding an accident are better if he could see better. Arguments that narrower front pillars would let the roof fall on him, cost too much, or spoil the styling are not satisfactory answers. From the motorist's point of view, the engineer is still on the defensive.

At least both engineers and industry should convince him they're trying constantly to improve vision.

Efforts must still be made to minimize front pillars and no draft vertical strips, despite structure, cost, and styling problems. They create blind spots

*Paper "Car Design Factors in Highway Safety," was presented at SAE National Passenger Car and Production Meeting, Detroit, March 4, 1948.

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which make it easier for the poorer driver to have an accident.

To redesign completely the front end of the car solely to be able to see the front bumper when it hits a pedestrian or vehicle is of slight value. Seeing the impact doesn't help prevent it. In almost all cases where the moving vehicle gets within 5 ft of an accident, it's too late to do anything about it.

WINDSHIELD WIPERS

If the purchaser were sufficiently interested, it seems somewhat obvious that the engineers could produce a wiper that would clean more than about 50% of the windshield area. If it could be improved to a point where it could clean about 75% of the area, this would undoubtedly help prevent many accidents.

With all due regards for the vast improvement of the automatic windshield wiper over the hand wiper, it has not much enlarged the peep-holes it provides in rain and snow since it was first invented. It certainly has not kept pace with the other engineering improvements in tires, engines, transmissions, and riding comfort. From the strictly safety point of view we have 1949 car models equipped with 1926 windshield wipers.

Such an improvement will naturally involve mechanical complications, additional cost, and adjustment of other design elements. But this is exactly the same stage that all car design elements have gone through. The question is really not whether we have the best practical device; it's one of how much engineering brains and management encouragement is being applied to the problem.

Windshield wipers for rear windows obviously have safety value, especially because sloping designs catch snow and dirt. It is hoped that ways and means of making them more easily available, more easily installed, and less costly will be found. Certainly, as a safety item, they should be encouraged by the automotive industry as well as safety officials.

Sealed beam headlights were a tremendous safety improvement of which the industry can be justly proud. They provided much greater seeing ability with much less maintenance. They still leave the aiming and glare problem to be solved. It is sincerely hoped that some new principle similar to polaroid or some other device can be applied practically. This will be specially valuable because it ultimately will make possible still more light on the highway. We are yet a long way from being able to see as well at night as we can in the daytime.

It is hoped that a general smoothing out of assembly problems and closer inspection will result in cars delivered having headlights correctly aimed, instead of some garage mechanic trying to adjust them without any testing device.

LIGHTING TELLTALES

With the average motorist as lazy and preoccupied as he is, a telltale which would advise the motorist that a light is out has some practical value - if it can be done cheaply enough. It simply is asking too much of human nature to expect an average motorist to open the door, turn on his lights, and walk around the car every time he goes out at night. An automotive engineer might do it, but not an average motorist. If you want the motorist to fix a light when it burns out, then some device must tell him when. Otherwise he is always going to say after the accident, it just went out.

The less often the motorist has to have his lights repaired, and the less chance of error the mechanic has, the less chance of light failures causing an accident there will be. Assuming better motorists and better mechanics is not likely to reduce accidents from this source in the immediate future.

URGES BETTER STOPPING

Let's assume that the car of tomorrow will have more effective glass area; that it will be kept useful by improved windshield wipers, defrosters, and windshield washers; that lighting has been improved; and that the driver now has a better chance of seeing the emergency coming. Next basic design factor is how fast can the motorist stop the car to avoid an accident, having seen the emergency coming.

If a driver can see the emergency in time and stop in time, it is obvious that he would not run into anything. The present rate of deceleration is about as

high as the passengers can stand, so little gain remains in this direction.

The facts are clear that one out of three cars has faulty brakes due to driver neglect. Obviously these faulty brakes are a factor in many cases of either contributing to the accident or in making it more serious.

Let's analyze the sharing of the blame for this situation.

First, the driver should get his brakes fixed when they need it.

Second, the garage should do a good job of fixing the brakes when the driver brings the car in.

Third, if the engineer could design the brakes so that they took less maintenance and make average maintenance more apt to be correct, this would help to compensate for the natural human errors of the driver, in not going to the garage often enough, and of the mechanic committing an error.

Since we know, for sure, that motorists will forget and that mechanics will make mistakes, then designing to compensate for these errors would seem a profitable investment in safety.

SPEEDOMETERS AND SAFETY

The speedometer is today an unwelcome spokesman for the automobile industry. It advertises how fast the car is going and how fast it will go. It is a present day reminder of the past — when one of a salesman's most effective selling points was how fast the car could go. It still remains an instrument which teen-agers use to see how high they can make the speedometer read.

It is a little confusing to the public for the industry to maintain that it is deeply interested in safety (which it sincerely is) and then equip all cars with speedometers that read over 100 mph — especially when it is agreed that: (1) speed too fast for conditions causes more accidents than all other causes put together; (2) when few of the low priced popular makes of cars will do over 90 mph under average conditions; and (3) when questionnaires indicate that most motorists do not want a higher top speed because there are not enough highways that will take it with safety.

If the industry were to undertake to make a speedometer do a maximum safety advertising job, the dial would probably read in terms of braking distance rather than miles per hour — since it is how fast you can stop rather than how fast you can go that prevents accidents. This, however, is impractical because it would not give the motorist the information he needs in terms of speed regulations.

To be of greatest value to the motorist for safety and to avoid being arrested, there are two speed figures which are most important. They are 25 mph, which is the legal speed limit in almost all American cities and 50 mph, which is the ceiling legal speed on highways in many states and may become the ceiling in a great many more. Since these laws are based on accident experience, they are certainly mile-posts to the motorist who knows that to go beyond them is to run the risk of being arrested and that to drive faster than these limits, requires double or triple caution in driving. It would seem reasonable for the speedometer to "talk to the motorist" and advise him when the car is going beyond these limits.

These two limits or speed figures, have many times the safety value of all other figures on the speedometer. They should be emphasized in design, by location, by size, and possibly by special illumination.

A speedometer that emphasized 25 mph and 50 mph and did not emphasize speeds over 100 mph would certainly be a better safety spokesman for the automobile industry. If the stylist would permit, this could be emphasized by having rapid point of movement in the lower ranges and slower point of movement in the upper ranges.

Looking up and down from a speedometer to the highway creates a vertical version of the neck and eye swing of spectators at a tennis match. Drivers simply will not do much of it. It is, therefore, highly probable that most drivers do not know how fast they are going and this situation can't be cured unless speedometers can talk to motorists with less effort on the part of the motorists.

BETTER ROADABILITY NEEDED

Arrangements for steering have been improved to a point where ordinary maneuvering is quite satisfactory and blow-

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outs are far less apt to cause the driver to lose control of the car. But some problems still remain.

When a cross-wind blows a car over in front of oncoming traffic or a car in the rear attempting to pass, a serious accident occurs. It is of almost no practical value to say that it was the driver's fault, that he should not have been given a license, and that more traffic law enforcement would have slowed him down.

This same motorist drives at the same speed when there is no cross-wind. Few of them are willing and able to compensate for the unexpected change in wind velocity.

We must either accept these deaths or cure them by engineering means — by better roadability and by a design which will make adjustment less complicated. Here again we are confronted with the fact that if engineers were to be even more "service conscious" than they are today, safety would be much less of a problem.

Automotive engineers must assume that when the collision occurs and the occupants are hurled against the inside of the front of the car, design factors can make a similar difference between injury and death.

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Since it is certain that hundreds of thousands of customers will hit the windshield, dashboard, and steering wheel next year, this is a fruitful place for engineering improvements which will remain within the limiting factors of attractiveness and economic possibility.

ATTITUDE OF THE ENGINEER

It is assumed that the average automotive engineer sincerely believes that he as a professional, is a little brighter than the average driver. He is thus violently irritated when he reads in the paper what stupid thing some driver did that caused an accident. If it merely makes him disgusted, then he will throw up his hands and say, "What's the use." In such a frame of mind, it is unlikely that he will make much use of his engineering ability to make cars inherently safer than they are today.

Or the engineer can react in another direction. He can say to himself, "Some motorists are sheer geniuses at outwitting the engineer. But I am going to outsmart them. I am going to design safety features which will work no matter how many things they think up."

The engineer must swallow the bitter pill that he is a very poor "guinea pig" as an average driver. He has to look at the dumb things some people do and figure out a way to overcome it by engineering design. He must assume dumbness, laziness, forgetfulness, and unskillfulness. And with the tools at hand he must do the best he can to save life — even if the man, woman, or youngster whose life he saves may not appear to be willing to try very hard to save his own.

It also must be remembered there always will be members of society who will accuse car designers of causing traffic deaths, just as long as there remains a single item which can be pointed to as having either contributed to an accident, or having failed to prevent one. Thus, as an important part of the total automotive industry, the engineer must so position himself publicly that he is recognized as trying desperately hard to do everything possible to "preserve the customer."

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

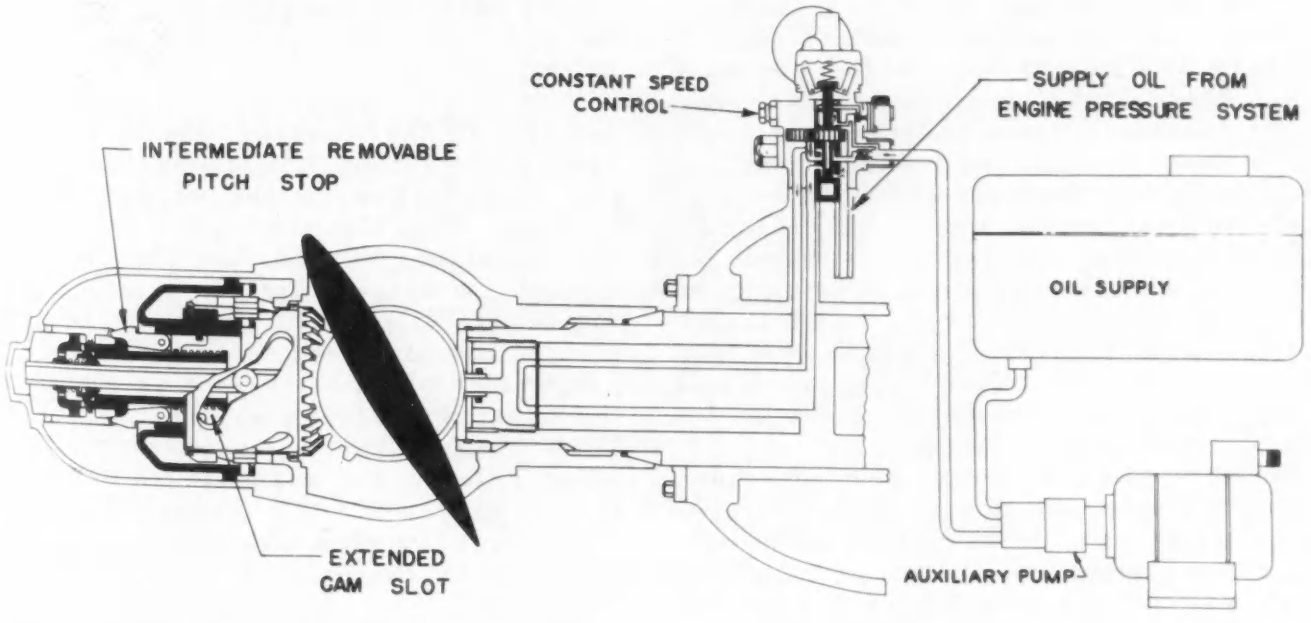
NEW HYDROMATIC PROPELLER Reverses Blade Pitch

FROM A PAPER* BY **Carl F. Baker**
Chief Engineer,
Hamilton Standard Propeller Division, UAC

THE hub mechanism and control system of the Hamilton Standard Hydromatic propeller have been modified for a new reversible pitch model which produces negative thrust - at negative blade angles - for landing braking.

Three major changes were made: The single-acting hydraulic system was replaced with a positive double-acting system. The cam slot in the hub mechanism - which is used also for changing pitch and feathering - was extended at a steeper angle at the end opposite the feathering range, and a new intermediate low-pitch stop was added. The hydraulic sys-

*Paper "The Reversing Hydromatic and Its Control," was presented at SAE Annual Meeting, Detroit, on Jan. 15, 1948.



●Fig. 1 - Complete hydraulic system of the reversing Hydromatic propeller

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tem used for the feathering operation was adapted for reversing, under separate actuation. Fig. 1 shows the new system.

Here's how the modified Hydromatic propeller system works:

When an increase in blade pitch is required to maintain constant speed, oil pressure exerted against a piston moves the piston and attached cam rollers in the axial direction. The axial motion is transformed into rotary motion of the blades by the cam rollers acting in helical cam slots. And the extreme high-pitch range of the cam slots is used for feathering. This much of the new Hydromatic propeller is similar to the older, nonreversing type.

PASSAGES DOUBLED

For decreasing pitch, new passages have been added to carry oil to the other side of the propeller piston. (Older models used the blade centrifugal twisting moment, supplemented by engine oil at constant pressure, to decrease blade pitch.)

Double passages for hydraulic oil were already available in engines because propeller engineers had foreseen the need for reversing and had been recommending this modification to engine builders for some time. Connecting passages were added in the propeller hub, as Fig. 1 shows.

These double passages made it easy to modify the hub mechanism for positive fast blade angle reversing to the negative position. Since positive oil pressure could be applied to the propeller piston in the decrease-pitch direction, all that was needed was an extension of the cam slot at the low-pitch range. The slope of the extension was made steep so that the blades would turn rapidly. The existing mechanical low-pitch stop was converted into a fixed negative blade angle stop merely by setting the stop for the desired negative angle.

Added to the system was an intermediate low-pitch stop, which acts as a positive stop except when reversing is demanded. When the blades are at low pitch three dogs engage the propeller piston to prevent its movement farther in the decrease-pitch direction. The dogs are locked in position by a spring-loaded mechanical wedge. Only application of high oil pressure - higher than the constant-speed control pump sends - in the decrease-pitch direction can withdraw the wedge.

The sequence of actions for reversing begins with the propeller against the intermediate stops. Oil pressure is applied to the propeller piston and to the piston attached to the stop wedge Neither piston moves until the oil pressure builds up to the pressure needed to withdraw the wedge. Then with the wedge out of the way, the propeller piston moves the dogs out of the way, and the blades are moved to the negative-pitch stops.

For unreversing, oil pressure is applied to the opposite side of the propeller piston, and the blades move in the increase-pitch direction. When the piston passes the position of the intermediate stops, the dogs - acted on by centrifugal force and by the spring backing up the wedge - move into position. The wedge seats itself to hold the dogs in position.

ACTUATION OF REVERSING

Since the direction of blade motion is the same for reversing and unfeathering, for unreversing and feathering, the feathering control system could take on the reversing function, although a different means of actuation was needed. On the new, reversible-pitch Hydromatic propeller, feathering is actuated by a push-button in the cockpit, but reversing is actuated by the throttle. The throttle is arranged so that the closed-throttle position is toward the middle of the quadrant. When the pilot wants to reverse the propeller, he pulls the throttle back through the closed-throttle position. The farther back he pulls the throttle, the greater the power and reverse thrust.

Some sort of throttle stop is placed at the neutral position so that the pilot knows when he passes into reverse. For added safety, the aircraft is designed with a safety latch - released either automatically when the plane contacts ground or by the pilot - which prohibits reversing.

When the throttle enters the reverse sector of the quadrant, it trips a switch which energizes first a solenoid-operated

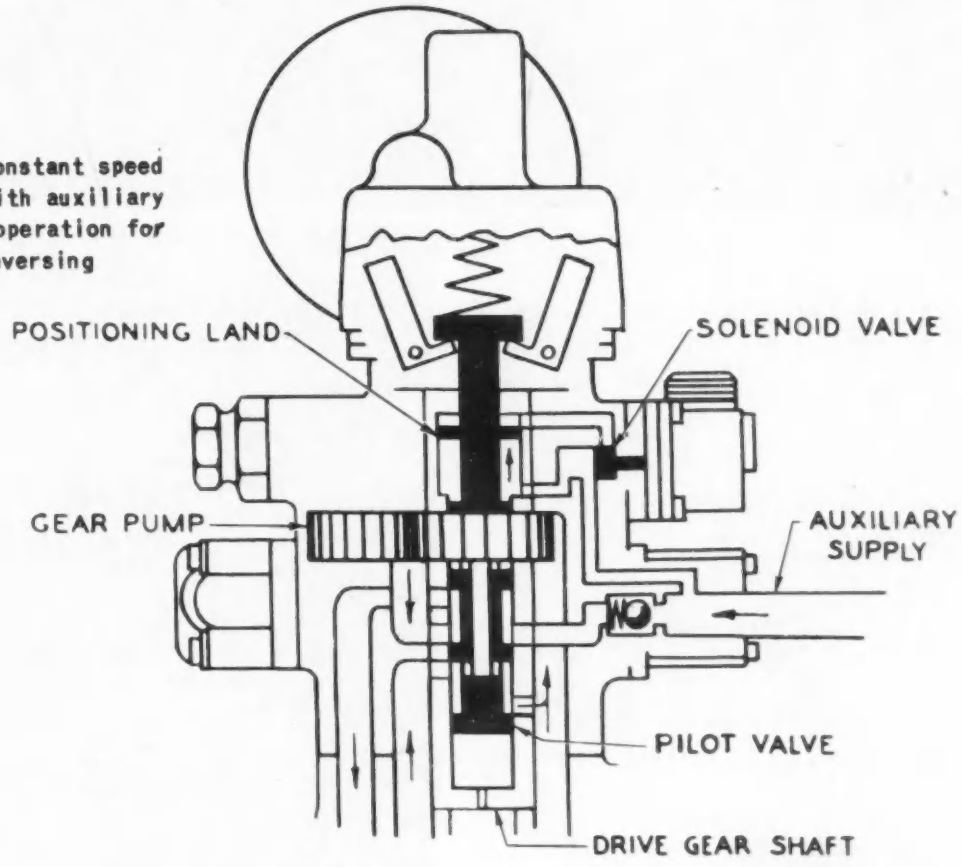
valve in the constant speed control and then an electrically driven pump which supplies auxiliary oil for reversing and feathering. The solenoid-operated valve, shown in Fig. 2, allows the auxiliary oil to act against the pilot valve, moving it to a position where it directs both auxiliary oil and constant-speed-control oil through passages to act on the propeller piston in the decrease-pitch direction. The pump draws the auxiliary oil from the engine oil supply tank and supplies it at high pressure to the constant-speed control. The high pressure of this oil overpowers the governing function of the control and opens the intermediate low-pitch stop in the hub.

When the propeller blades are up against the negative-pitch stops, the pressure rise causes a pressure cutout switch in the control unit to break the electrical connection to the auxiliary pump.

For unreversing, the throttle is moved forward toward the neutral position. Throttle-actuated switches first de-energize the solenoid valve in the constant speed control, allowing the valve to direct oil to the increase-pitch passages. (See Fig. 2.) Then the throttle switches energize the electrically-driven pump for auxiliary oil. Pumping continues until the propeller piston has moved the blades to a point just beyond the low-pitch stops. An electrical angle-sensing device on the blade senses when this point is reached and shuts down the auxiliary pump.

With the termination of high oil pressure, the governor takes over control of propeller blade angle.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



● Fig. 2 - Constant speed control with auxiliary system in operation for unreversing

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PROCESS CONTROL Steps Up

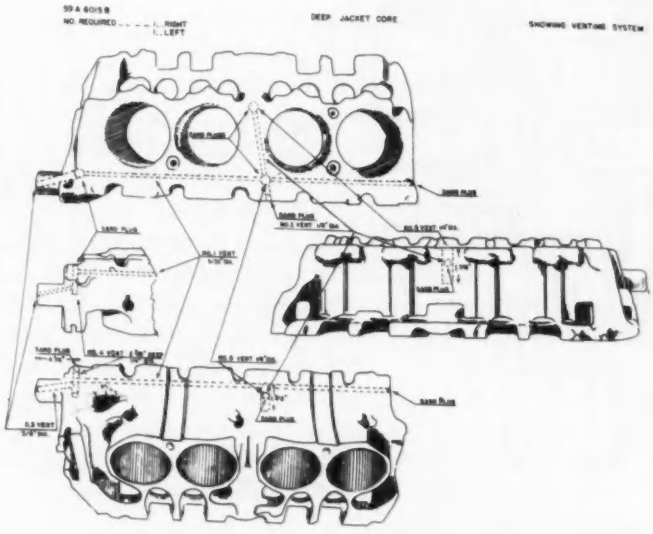
EXCERPTS FROM A PAPER* BY
the late R. H. McCarroll
FORD MOTOR CO.

PROCESS control is the best way of getting much-needed quality control for many types of manufacturing operations. At Ford, process control sections in many different manufacturing departments help increase quality, lower costs, and increase volume of production.

Aside from its normal duties, this section also aids manufacturing in many other ways. Particularly important are these two: (1) suggesting improved methods or equipment and (2) training supervisory personnel for manufacturing departments. For example, a former supervisor of process control in the foundry section suggested a new method of core assembly and dipping on a cylinder block, cast in the gray iron foundry. It reduced cost, lowered repairs and scrap rate. Incidentally, this man is now assistant manager of Ford Foundries. Many department heads and supervisors came up through process control.

It is difficult and often impossible to separate examples referring only to improved quality, reduced costs, and increased volume of production. They all go hand in hand. For this reason, the examples that follow are presented by manufacturing unit or types of work done - foundry, forging, plating, cold heading, and statistical quality control.

Foundry



One way of minimizing rejections in foundry work is through venting to prevent blows. Vents must be properly located and kept open at all times during mold assembly to aid in removing gases.

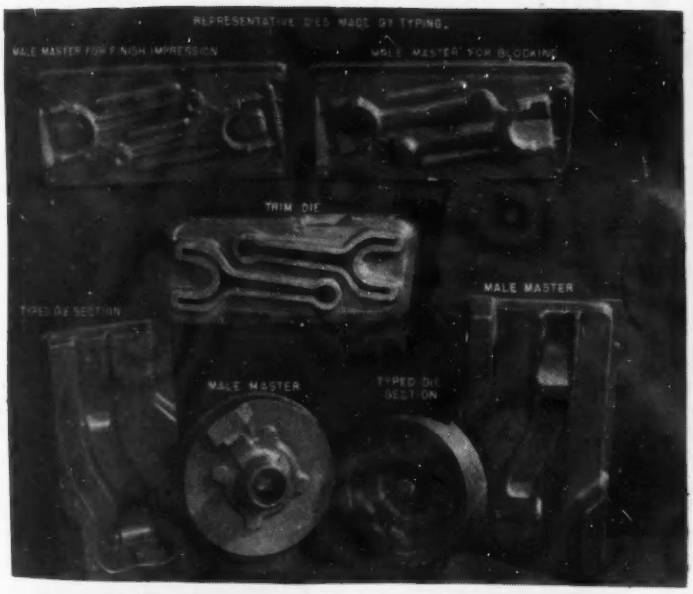
The sketch at left shows size and location of all vents in a deep jacket core of the Ford cylinder block.

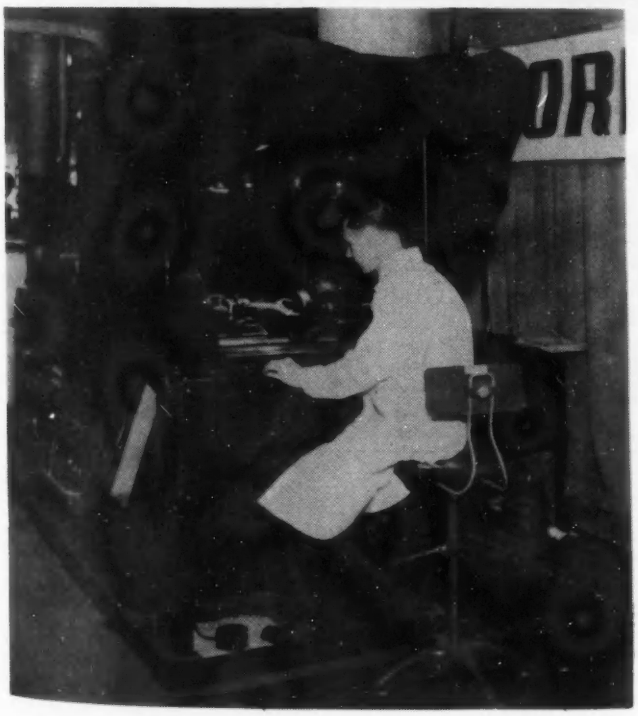
Metal pouring temperatures also must be controlled. Allowable limits are definitely specified on all castings. Generally temperatures are taken optically, but checked regularly with immersion pyrometers.

*Paper "Production Process Control, What It Can Do for Quality, Costs, and Volume," was presented at SAE National Passenger Car and Production Meeting, Detroit, March 3, 1948.

Production, Cuts Costs

Forging





In the upper left is shown a display of dies with characteristics making them suitable for hot typing. Typed dies are both cheaper and longer-lasting. Less dies are being made by cutting; the proportion of dies made by typing is growing.

Making a forging die by typing, shown in upper right, consists of forcing a master into a heated block of die steel. There is little or no machine work to be done on these typed dies. The hammer for this die is of 5000-lb capacity.

More forged parts are being manufactured scale free, without pickling, and magnetic particle inspection (at left) is supplanting visual inspection. This method lends itself well to full automation, with greater production, per worker and reduced costs the result. Fewer parts that are satisfactory are

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rejected and fewer parts with objectionable defects are passed for reconsideration.

Savings on a complete fluorescent magnetic inspection unit for connecting rods were so great that cost of the equipment and installation, it is estimated, was amortized in about seven months.

Another forging suggestion made by the Process Control Section at Ford was the switch from the upset and hammer method to the hot extrusion method. The table below points up the advantages of the latter method. Particularly noteworthy are the economies in machine tools and equipment, manpower, and floor space. These requirements are based on a daily production of 900 forged front spindles.

Required Equipment, Personnel, And Floor Space for Forged Versus Extruded Front Spindles

FORGED SPINDLES

1 – Shear (weight for 2 spindles - 15 lb)

5 – Ford Slot Type Billet Heat Furnaces

5 – 4-in. Ajax Upsetters

1 – Grinder (Snag when necessary)

4 – Ford Slot Type Billet Heat Furnaces

4 – 2500-lb Erie Steam Hammers

4 – 55½ Toledo Trim Presses

4 – 56 Toledo Restrike Presses

2 – spindles for forging
Weight of forging – 15 lb
Weight of machined spindle – 3.70 lb
Personnel Requirements (2 shifts) 46 men
Floor Space Requirements – 5000 sq ft

EXTRUDED SPINDLES

1 – Shear – 5¼ lb

1 – Tumbler

2 – 700 KVA Induction heating unit with two heaters

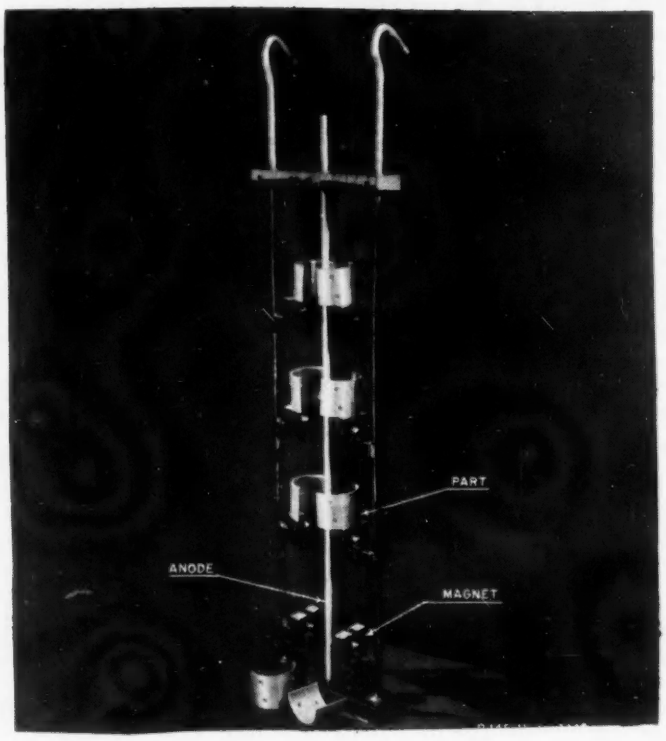
2 – #5 National Maxi-Press

1 – Trim Press

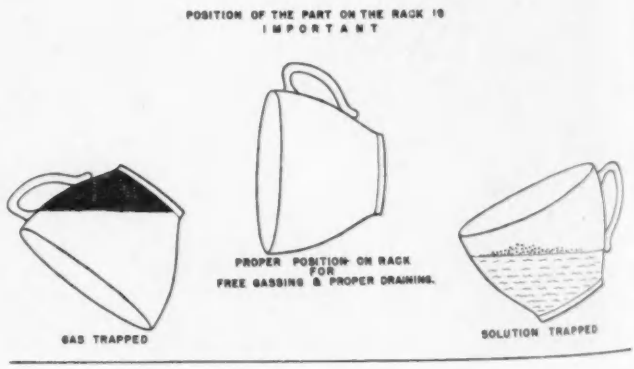
2 – Double Wheel Grinders

1 – spindle per billet
Weight of billet – 5¼ lb
Weight of machined spindle – 3.85 lb
Personnel required (2 shifts) 16 men
Floor space requirements – 1000 sq ft

Plating



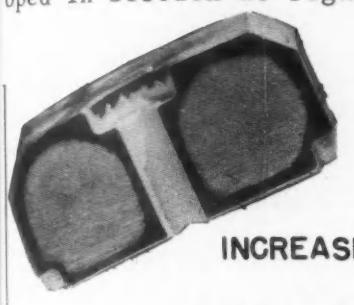
The permanent magnets on the plating racks at left have been found advantageous in many cases for holding the part during plating. These racks were developed at the suggestion of a process control engineer. Below is a diagram, prepared for educational purposes, showing how much difference position of a part can make during plating.

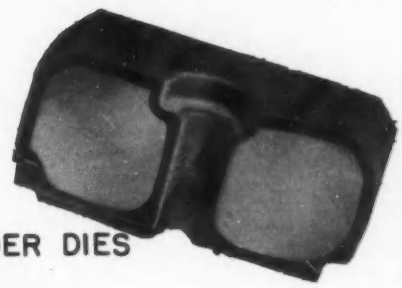

POSITION OF THE PART ON THE RACK IS IMPORTANT
PROPER POSITION ON RACK FOR FREE GASSING & PROPER DRAINING.
GAS TRAPPED
SOLUTION TRAPPED

Cold Heading

The macro sections of cold heading dies (below) show proper and objectionable heat-treatment. Section at left indicates lack of proper hardening where it's most needed. (Darker section is the hardened area.) Right depth of hardness was developed in section at right through proper quenching procedure.

The poorly-quenched die produced 8000 pieces; properly-quenched die yielded 34,000 pieces. The chart shows increased production of a few cold-headed dies after Process Control corrected treatment of dies.

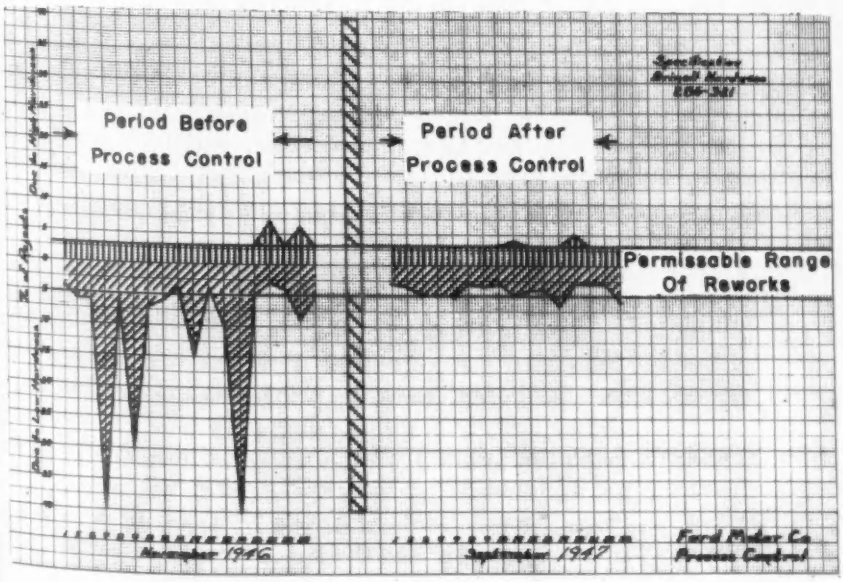




INCREASED PRODUCTION ON COLD HEADER DIES DUE TO CONTROL OF GRAIN SIZE, HARDENABILITY & HEAT TREATMENT OF TOOLS

AVERAGE PRODUCTION BEFORE CHANGE	AFTER CHANGE	CHANGE MADE	EST. TOOLS SAVED PER YEAR BASED ON 1946 PROD.	TOOL COST EACH	EST. SAVING PER YEAR
40,000	60,333	STEEL & HEAT TREAT	51	$ 4.35	$ 221.85
10,000	20,430	"	125	10.19	1273.75
30,000	33,500	"	35	4.85	167.75
35,000	49,375	"	403	5.35	2156.05
2,800	4,500	"	256	30.00	7680.00
			TOTAL SAVING PER YR. ON 5 DIES		$11,499.70

Statistical Quality Control



Though still in its infancy at Ford, statistical quality control has achieved some interesting results.

The control chart at left depicts the situation before and after process control on heat-treatment hardness of spindles.

In other cases statistical quality control has given a record of how the process is doing. Erratic conditions signal the shop to look for assignable causes - such as poor workmanship or unsatisfactory machines.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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PROPOUNDS FUNCTIONAL P

EXCERPTS FROM PAPER* BY

GROUPING inspection steps according to life expectancy of truck and bus parts and adjustments, and recording all replacements and repairs, makes up a positive and commercial preventive maintenance program. Truck parts and assemblies fall into certain life expectancy groups, depending on ability to resist wear—because of physical properties or dimensions, design or strength of devices to maintain tolerances, and capacity or capability of cleaning devices to insure uninterrupted operation. Due to factors not entirely within the control of the designer, these groups have a wide-range of life span. Life beyond certain limits is not expected from any of the units in the various groups.

But a well-selected list of lubricating, tightening, adjusting, and cleaning procedures, timed properly for each group, assures satisfactory vehicle performance under any circumstance. Inspection operations, carefully selected and timed accurately for each group, uncover need for further attention—other than the preventive maintenance steps—which automatically arranges to return the part or assembly to a safe working condition.

The manufacturer through his engineering tests and service records builds up an experience with each model of his line as to the life expectancy of individual parts, he is therefore, in a position to select inspection intervals fairly accurately. But there are other factors that must be considered if proper preventive maintenance procedures appear in every contract he accepts. He must also analyze those factors pertaining to the customer's transportation operation.

OPERATION INFLUENCE

He must know important specifications, present and anticipated annual mileage, also pertinent facts regarding the operation and speeds, condition of roads, size of loads, and length of daily hauls.

This information tells many things that may be necessary to develop a plan to adequately protect the vehicle in the work outlined.

For example, this is how varying operating factors affect the development of adequate preventive maintenance protection: Two vehicles of equal capacity work under conditions that are entirely opposite - one hauls normal loads, over level terrain, at reasonable speed, on good roads; and the other is continuously overloaded, in hilly country, over poor roads at high speed.

Obviously the second vehicle will require more variation in a preventive schedule than the first vehicle. We would consider one normal and the other abnormal and design the schedule accordingly. Certainly in one case closer attention must be given the entire vehicle - with particular emphasis on engine and ignition, unit lubrication, cooling system, springs and brakes, drive, and drive

*Paper "Factors that Determine the Proper Intervals Between Preventive Maintenance Procedures," was presented at SAE Annual Meeting, Detroit, Jan. 12, 1948.

PREVENTIVE MAINTENANCE

W. J. Cumming

Field Service Manager

The White Motor Co.

lines.

But total anticipated accumulated mileage annually is the factor generally having greatest bearing on frequency of inspection intervals.

All preventive steps, in all maintenance plans, are similar because they are all fundamental; therefore frequency of inspections is the controlling medium in arriving at an economical and adequate annual schedule. Although annual first year mileage may be low, remember that schedules for subsequent years must be expanded to provide for the accumulated mileage. Increased mileage calls for heavier inspections if the preventive maintenance plan is to be an economical one.

MODIFICATION WITHIN FLEET

This same flexibility can very readily be applied to the fleet preventive maintenance schedule. There are two classifications found in many fleets that offer comparison, the low mileage pick-up and delivery and the high mileage over-the-road group. Certainly in the annual schedule of inspection operations, no single list of procedures will fit both forms of transportation; and the difference does not lie entirely in the wide variation in total annual mileage. Operating conditions again play a considerable part in the changed requirements.

An analysis of the two transportation requirements will indicate need for careful attention to, and more frequent inspection of: ignition and fuel systems, drive and drive lines, lubrication, and certain chassis items for over-the-road vehicles; and clutch, brakes, and engine lubrication items for the pick-ups. A different schedule for each is necessary to gain economical maintenance for the fleet.

Another important, but frequently-overlooked angle in designing an inspection operations sheet is the sequence of procedures. We have found that a short test before actual inspection work begins is desirable - a 5 to 10-min interval is sufficient. This part of the inspection is preliminary and visual; but noting the result is a lead-up to possible later developments. Same is true of a check of the driver for complaints, which, often develops a hint of trouble that may not be too obvious.

Natural sequence of procedures is generally maintained by listing mechanical steps from the front of the vehicle to the rear on one side, and from back to front on the opposite side. This is important to maintenance of economical overall labor cost. It allows proper sequence of dismantling steps—particularly in the heavier, long-lived units—when internal inspections occur.

In other words, as inspection progresses, certain dismantling procedures take place until the unit requiring an internal inspection is exposed or ready to be exposed.

PARTS LIFE PATTERN

Using those invaluable experiences regarding our own product gained through

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engineering tests, technical service reports and preventive maintenance results in the field, together with comparative preventive maintenance results with other competitive vehicles, we have determined the average maximum life expectancy of adjustments, parts, or units of vehicles under normal operating conditions. Within reasonable limits they fall into five maximum mileage groups, so that lesser mileage—but never more—can be applied to any group.

With this information established, we have assigned inspection procedures required to assure the satisfactory performance of certain parts and units to each of the five groups.

Lubrication, because of its basic importance to the entire idea of preventive maintenance procedure, becomes the first consideration in our plan. For easy identification we call it Operation "L". Further, in the commercial scheme contact with the vehicle (due to circumstances beyond our control) is at times intermittent and not continuous; we therefore set the lubricating periods at the 2000-mile maximum mileage point in every contract.

As an additional provision in the case of low annual mileage city operations, we stipulate also that the period shall not exceed 30 days. We recognize that under the most critical conditions there are certain units that may require attention at this same low mileage interval. For this reason we include the inpection of such units as battery, air reservoir, lights, mirrors and signals, cab glass and interior, radiator, and tires. The entire time involved is reasonable and we do not consider overservicing as a serious possibility.

Note that every method available has been used to insert maximum flexibility into the five groupings. A rearrangement of a group or of individual inspections in any group is possible so that we may design a schedule to fit varying transportation requirements.

For this reason we have arranged the units with the shortest life expectancy, or those that will require attention most frequently, into the first group or Lubrication Operation "L." Those in the next frequency group or second group we designate as Operation "A," on into the third, fourth and fifth groupings which are known as Operations "B," "C," and "D."

In terms of maximum mileage, the group life expectancies are:

- "L" 2000 miles maximum,
- "A" 4000 miles maximum,
- "B" 20,000 miles maximum,
- "C" 40,000 miles maximum, and
- "D" 50,000 miles maximum.

Flexibility is maintained in two ways: first, by combining all inspection procedures of the first group into each succeeding group and second, by identifying each new item added to each succeeding group by a prefixed star. In other words, "A" includes "L," "B" includes "A" and "L," and "D" contains all of the steps in the five groupings. A star precedes all of the items in "B" that are not included in "A," and those in "D" not found in "A," "B," and "C."

Combining operations and performing as many as five operations at one appointment is simple with this method. This scheme also allows the mechanic to make all inspections by following one inspection form, which provides a proper sequence to be followed. Identifying each new item added to an operation allows modification to fit any variation in circumstance by simply eliminating certain named items in an operation and noting the change in the annual schedule. Too, an operation can be split (doing part at one mileage and the balance at another) by crossing out procedures in the form used at any appointment.

For example, a typical schedule for an abnormal truck operation of 25,000 miles a year would require the following twelve operations annually, one each month, but not more than 30 days apart, in this sequence: A, A, B, A, A, C, A, A, B, A, A, and Modified D.

In terms of individual groups it would actually receive:

- 12 "L" or lubrication operations,
- 12 "A" or the short-lived group,
- 4 "B",
- 2 "C" and,
- 1 Modified "D"

All of the above combine into a schedule of twelve monthly operations.

Selection of the proper inspection procedures or items to be inspected, assigned to each frequency group, is the most important single phase of the whole plan. In the lubrication group - Operation "L_4" - maximum mileage 2000 miles or 30 days, we include:

1. Lubricate all points of the chassis (including all accessories);
2. Inspect all units for oil level;
3. Fill radiator (test antifreeze in season);
4. Refill battery with water;
5. Inspect and lubricate all cab doors and hinges;
6. Clean interior of cab and cab glass;
7. Inspect all lights, mirrors and signals;
8. Inflate tires to proper pressure,
9. Drain air reservoir;

Our contact with items 2 and 3 is intermittent and should normally be more regular. We do, however, assure ourselves of a proper condition at the time of our inspection and correct conditions if necessary. All other items are well regulated.

Next inspection covers the comparatively short-lived group - Operation "A." This form includes those parts or units that will need attention at frequent intervals to assure satisfactory results, as regards both proper functioning of one unit alone and its relation to other units. For example, battery condition beyond "low water" may affect the entire electrical system. And belt adjustment—beyond actual condition of the belt itself—may affect the satisfactory operation of the water pump, generator, and air compressor.

Selection of units in every group, therefore, may depend not only on the conservative estimate of the life span of the unit or part alone, but on the relative importance of insuring satisfactory operation of other units.

In Operation "A" the first five items we consider visual inspections only; in the case of the following five items, the first step is a visual check, followed by an adjustment if necessary. All visual inspections can be made in the cab at the time of the 5 or 10-min test run.

Operation "A" includes the following steps in sequence:

1. Oil pressure - inspect idling and maximum with engine hot.
2. Speedometer - check for proper operation.
3. Instruments - all-check for operation.
4. Horns and windshield wipers - check.
5. Switches - check - all.
6. Choke assembly - check for operation - adjust if necessary.
7. Clutch, adjust if necessary - pedal lash 1 to 1 1/4 in.
8. Brake (hand) - check - adjust if necessary.
9. Belts - adjust if necessary - 1/2 to 3/4-in. deflection between pulleys.
10. Generator charging rate - inspect, reset if necessary.
11. Distributor Points - clean, dress and adjust.
12. Spark Plugs - remove, clean, adjust, and test.
13. Fuel Pump - tighten - clean bowls.
14. Carburetor - tighten bolts, clean screens, inspect for leaks.
15. Air Cleaner - clean and re-oil - refill oil-bath type.
16. Governor - check operation - reset if necessary.
17. Engine idling speed, adjust - 350-400 rpm.
18. Cylinder head nuts or cap screws - check with tension wrench.
19. Oil filter - replace cartridge - drain and clean case.
20. Oil level - check all units.

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21. Chassis - lubricate complete - use Operation Sheet "L" - change engine, axle or transmission lubricant if necessary.

22. Battery, check - should read 1.275 to 1.300 recharge at 1.225.

23. Rims and wheel stud nuts (front) - check and tighten - true-up wheel rims.

24. Toe-in - check, adjust if necessary - inspect tie-rod and drag-link ends.

25. Rims and wheel stud nuts (rear) check and tighten - true-up wheel rims - tighten axle stud nuts.

26. Brake (Service) check fluid level - adjust if necessary.

27. Tires - inspect for cuts, bruises and other irregularities.

28. Hoods, fenders, running boards, etc. - check for tightness and condition and report.

Note that the operations are arranged in a natural sequence, the foremost being performed with the vehicle on the floor, those following on the lift and the balance on the floor. Unless arranged in this manner, production is curtailed. Only lubrication and those operations that can be performed to better advantage occupy the lift at any time.

In Operation Form "B" we include not only those inspection procedures called for in both Operation "L" and Operation "A," but additional items with a life expectancy of 20,000 miles, each prefixed by a star and all arranged in a new sequence. The starred items read as follows:

1. Vibration Damper - check and tighten if necessary.

2. Distributor - lubricate according to Manual.

3. Condenser - check with analyser.

4. Coil - check with analyser.

5. Crankcase ventilation system - clean.

6. Oil filler cap - clean.

7. King pins and bushings - check and report.

8. Springs, shackles, pins, bushings and brackets (front) - check for broken leaves and center bolts - tighten clips and U-bolts - check for wear looseness.

9. Steering mechanism - check, adjust if necessary.

10. Springs, shackles, pins, bushings and brackets (rear) - check for broken leaves and center bolts - tighten clips and U-bolts - check for wear and looseness.

11. Fifth wheel mounting - tighten.

12. Windshield and lights - check and clean.

After completion of the "B" operation, at which time 40 individual inspections were made, follows frequency group "C" - having a life expectancy of 40,000 miles. Same identification of new items occur and the list reads as follows:

1. Clean engine.

2. Gear shift mechanism - check.

3. Radiator, water pump and lines - check for leaks - tighten mounting bolts.

4. Fuel pump - check vacuum and pressure.

5. Distributor - clean, check, and adjust with analyser.

6. High tension wiring - check.

7. Ignition primary terminals - tighten.

8. Timing - check, using timing light.

9. Starter - check brushes and operation.

10. Regulator, relays and connections - check.

11. Manifolds and exhaust system - all - check and tighten.

12. Compression in each cylinder - check with compression gauge.

13. Carburetor - clean, readjust.

14. Battery cables - check, clean, and tighten - apply vaseline.

15. Valve tappets - check for clearance.

16. Oil leaks in engine - check, tighten oil pan and bell-housing.

17. Differential to housing - tighten.

18. Propeller shafts - inspect for worn joints, tighten bolts, report wear.

19. Gas tanks, vents, lines - check.

20. Flexible hoses - all - check condition.

21. Brake System - all type units - check supply tanks, master, cylinder, connections, reserve tank, valves, slack adjusters, air compressor, vacuum unit - check and lubricate.

22. Body bolts, cab mounting bolts - tighten.

23. Wheel bearings (front) - remove, clean, repack and adjust – check brake lining for wear, wheel cylinder for leaks and drums for scores. Check oil seals.

24. Wheel bearings (rear) - remove, clean, repack and adjust - check brake lining for wear, wheel cylinders for leaks and drums for scores. Check oil seals.

25. Bumpers - tighten.

"C" Operation requiring 62 individual inspections (wherever possible preliminary operations in preceding groups are combined) is followed by the final "D" Operation. It contains the longest life group with an expectancy fixed at 50,000 miles. While there are but six new items in Operation "D," they are important to the plan and certain items are often called for in schedules of comparatively low mileage. This list reads as follows:

1. Cooling System - reverse flush.

2. Oil pan - remove, clean, check condition of engine, clean pump screens - report.

3. Engine supports and brackets - check and tighten.

4. Transmission cover - remove, check bearings and gears.

5. Rear axle center - remove check tooth contact and backlash and general condition - report - adjust if necessary.

6. Radius rods - check and tighten.

Reverse flushing the cooling system, being a seasonal inspection may, at the discretion of the service manager, be performed at any date he sees fit by recording the individual change in the master schedule. This remains true of any item or operation he desires to perform, if it will help the overall performance of the vehicle.

Naturally the quality and type of precision checking equipment and tools has a bearing on the speed and accuracy of all checking operations. Finally the accuracy of personnel is of the greatest importance. Without punctuality in the delivery of the vehicle for service, success cannot be expected either.

To insure a complete record of each step in the performance of our obligation to provide a satisfactory program for the owner, all inspections completed are checked on the form by the mechanic. Those not completed and, therefore, in need of repair are also checked. "Need attention" items are performed by another mechanic on a new repair order.

To eliminate deviations from this planned procedure, we provide an instruction sheet which describes all the mechanical procedures required by each inspection step in the program. It positively separates preventive maintenance from replacement and repair by printing the preventive maintenance steps in black and the repair steps in red. We use this sheet also as a training medium for preventive maintenance mechanics.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

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NEW CAR

BASED ON A PAPER* BY

E. O. Courtemanche

Welding Engineer, Briggs Mfg. Co.

THE new multi-transformer welding and poke spotwelding methods cut costs and time of car welding, which consumes 20% of the production man-hours at Briggs plants in Detroit and Evansville.

The multi-transformer welding technique, Fig. 1, uses a group of small transformers with one or more secondaries to each transformer. For the first time this method allows transformers to be placed close enough to the work so that very short secondary leads can be used between transformer and welding gun.

It also keeps secondary connections side-by-side as they should be, instead of in a large loop spread far apart, in hydro-matic and ultra-speed units. This compact secondary loop condenses transformer size, making for a smaller and neater machine.

ELECTRICAL LOAD LOWERED

The smaller secondary loop allows more transformers to be fired from each phase of a three-phase system, without imposing a larger load on the system. For example, four multi-transformers having four guns each can be fired successively on each of the three phases. This produces 48 spots at the same time, imposing a load of 160 to 200 kva on each phase.

To produce the same number of spots at once, the earlier hydro-matic and ultra-speed methods would require 400 to 500 kva on each phase.

In addition to this power-economy advantage, the multi-transformer does the job in a very much shorter weld time. The multi-transformer takes three separate firings or weld times to complete a 144-spot assembly. Assuming a weld time of 20 cycles, two cycles to change the firing relay from one transformer bank to the next one, 10 cycles squeeze time, and 10 cycles hold time, the total job would take only 84 cycles - a trifle over 1 1/2 sec.

For the same job, the ultra speed takes 3 to 3 1/2 sec and the hydro-matic 6 to 7 sec.

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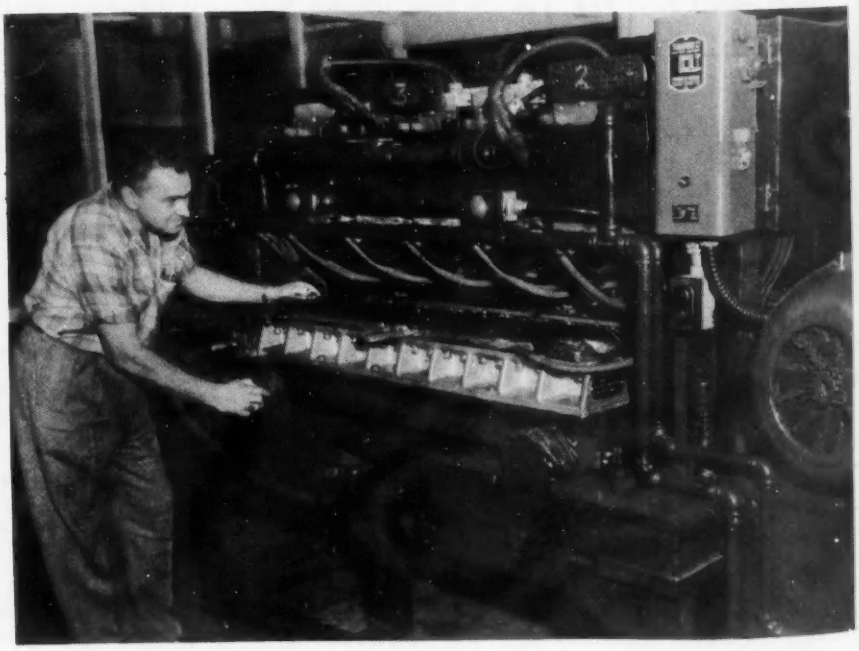
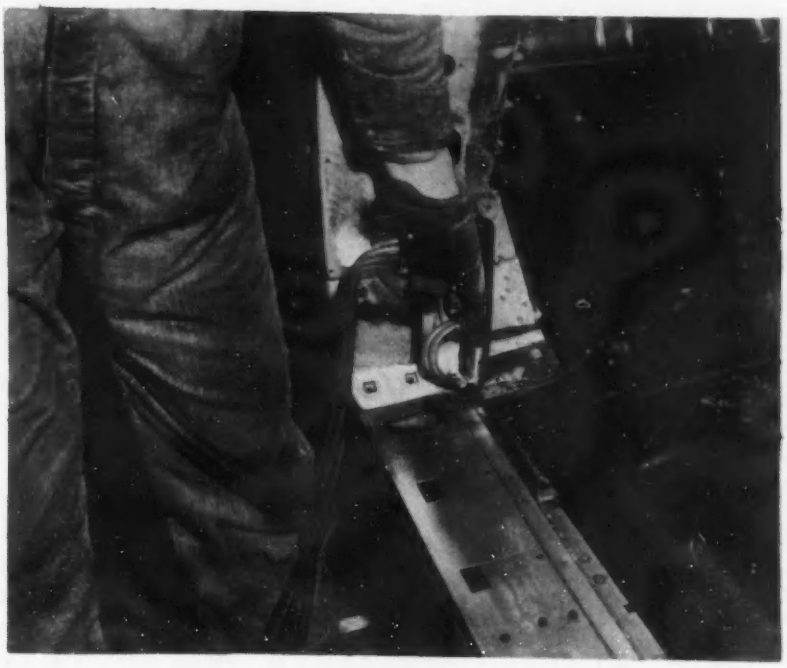
*Paper "Modern Welding Procedures in Building Car Bodies," was presented at SAE National Passenger Car and Production Meeting. Detroit, March 3, 1948.

● Fig. 1 - This multi-transformer welder operates better than twice as fast as



WELDERS Promote Economy

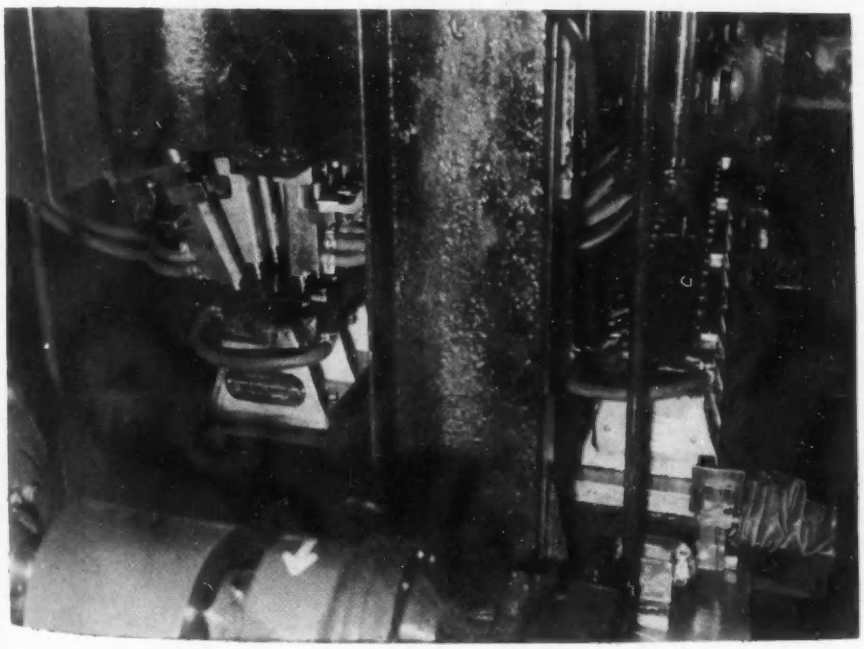


●Fig. 2 - The recently-developed poke spot-welder is designed for hard-to-get-to places

Multi-transformer welding speeds up the welding cycle of the machine and produces considerably more pieces per hour, provided better and easier loading methods are used to take advantage of the short weld time.

Second new advance in this field, poke spotwelding Fig. 2, uses a lightweight gun, a fixed electrode, a device for cooling the electrode, and a means for surrounding the weld area with argon gas.

previous methods on about half the power. Close-up of welder at work is at right



To make the weld, the operator pushes the gun against the work surface, opens a valve which starts the gas flowing, and closes a switch in the gun handle. This sends high-frequency current flowing from electrode to work piece.

The high-frequency current starts the high welding current flowing. After a preset time interval—which can be varied to suit the material being welded—both currents are shut off and the weld is complete. Chief use of this method is for places where portable welders can't be used. For example, it's particularly well-suited for boxed sections found at pillar reinforcements to the floor pan, seat risers to the floor pan, and similar locations.

As poke welding develops, it will become advantageous for many other applications.

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BONDED BRAKE LINING

BASED ON PAPER* BY **W. R. Rodger** Brakes Engineering Division

& **J. V. Hendrick** Rubber and Plastics Laboratory

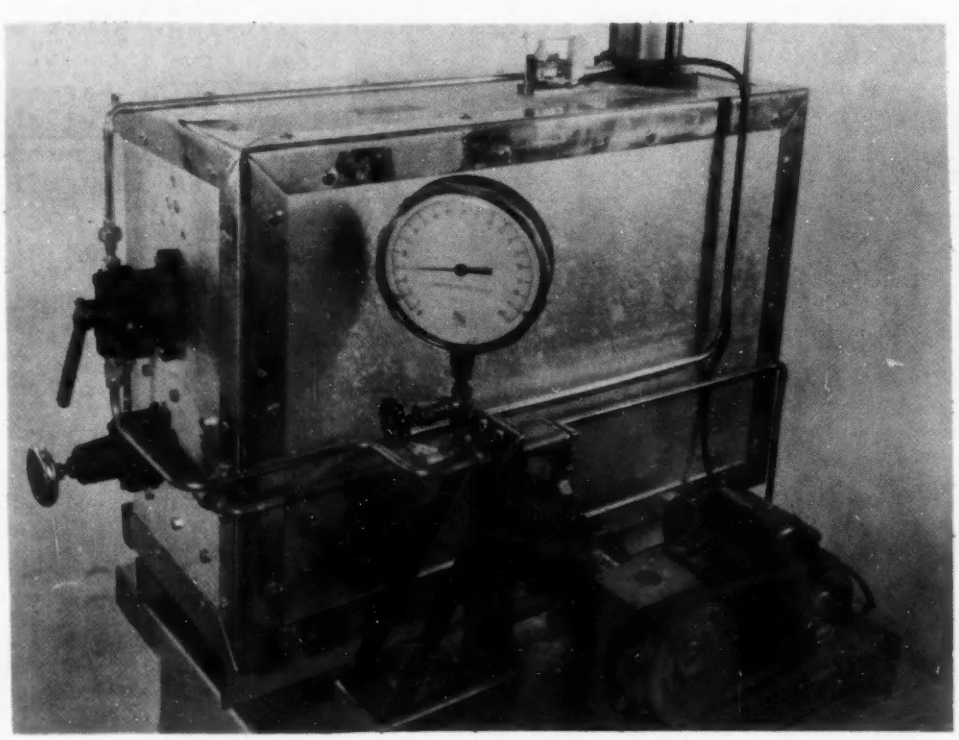
CHRYSLER CORP.

DEVELOPING production methods for making bonded brake linings was a less than simple problem. Nearly every phase of the job posed its own unforeseen troubles - which eventually were overcome.

Quick cures for cement proved to be elusive. Only after running into excessive bond failures did we find where and how to take proper temperature readings. Cement-curing troubles also fouled up shear test results. And experience pointed up the import of clean shoe surfaces.

A quick method of curing the cement is a must so as not to tie up a large number of production clamping jigs. High-frequency induction equipment had been used experimentally with some success. Although it gave satisfactory cures in 2 min, with cement line temperature reaching 350F, this cure was too slow for commercial production. Infra-red held little improvement over the old oven method, taking 20

*Paper "Bonding Brake Lining to Shoes," was presented at SAE National Passenger Car and Production Meeting, Detroit, March 3, 1948.



●Fig. 1 - Rear view of shear test apparatus showing cam and valve to give cyclic pressure

PROCESS
Geared to Factory Production

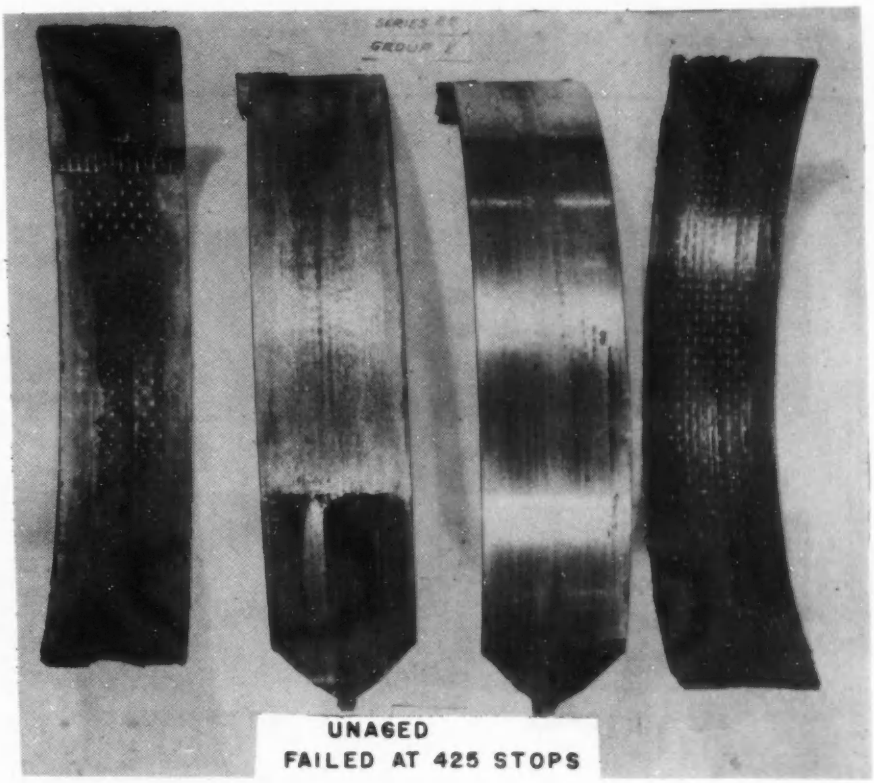
instead of 30 min.

During the investigation of various heating methods, it was known that the cement would cure properly in 15 min if the temperature were 315F. But to cure the cement in this length of time, the oven must be set considerably higher than 315F to raise the cement line temperature to that figure in the shortest possible time. Shoe size and oven type greatly influenced this temperature.

We were reluctant to cure cement at cement line temperatures higher than 350F for fear of disintegrating the cement or harming the brake lining. Additionally, the shoe rather than the lining had always been cemented to prevent oxidation of the cleaned shoe.

While experimenting with other bonding applications, it was found that the cement could be cured quickly if the metal component was not cemented, but heated to a relatively high temperature and then applied to a cemented surface. A method similar to this one in principal was adapted to brake lining bonding and remedied many ills.

First, curing temperatures considerably



●Fig. 2 - Presence of zinc plating on these bonded brake shoes led to bond failure on the inertia dynamometer

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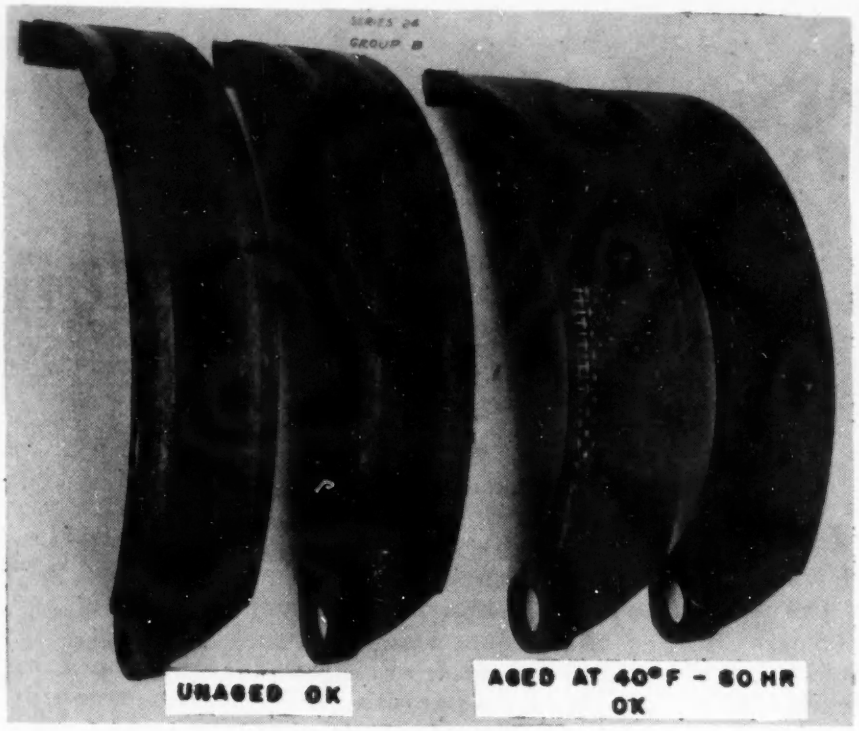
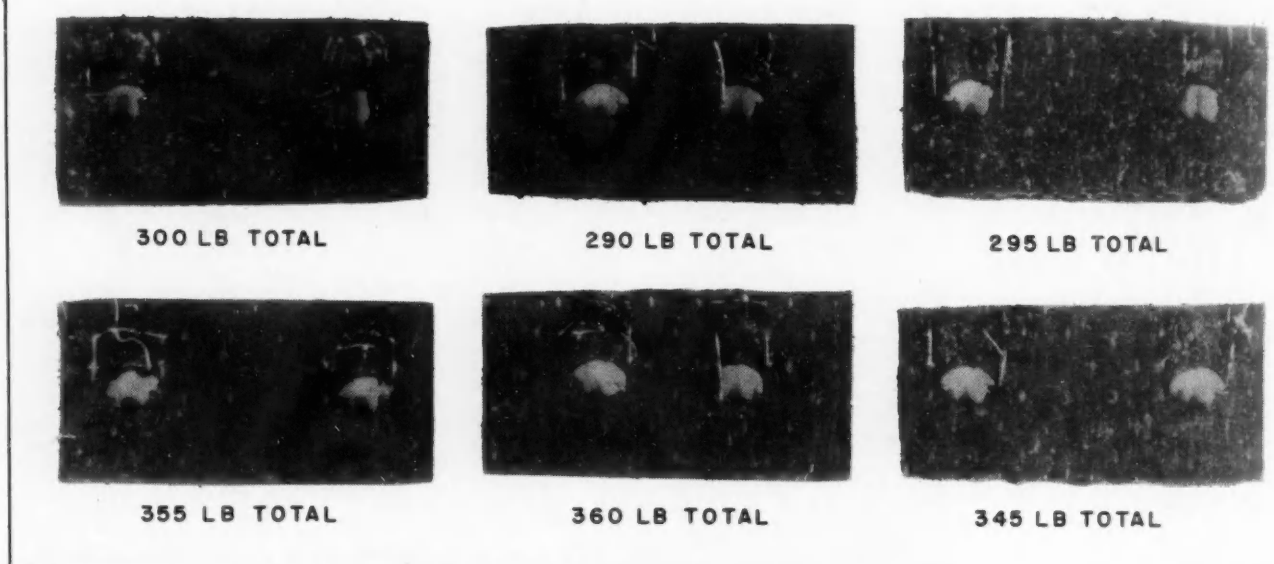


● Fig. 3 - These brake shoes were belt ground, completely removing the zinc plating to give a good bond

higher were used - 400F and 425F versus 315F - which speeded the cure. Second, heating the metal component of the assembly brought the cement line to maximum temperature almost immediately. Third, the lining was never overheated, except for a very thin section at its faying surface.

Though simple and effective, this method

● Fig. 4 - Total strength of a shoe-lining assembly with riveted linings at left is 1200 lb. Bonded linings, at



also was too slow, even if the shoe had been preheated before being placed in the hot clamping jig. Higher temperatures were tried to shorten the cure, but were unsatisfactory; the cement precured and a skin, formed over its surface before getting complete clamping pressure, produced an unsatisfactory bond.

A modification of this process - the Hot-Shot method - turned the trick. It consists of a partial cure of 30 sec, followed by a final low-temperature cure in an oven or bank of infra-red lights after removal of assembly from the clamping jig. The high-temperature precure softens the cement and partly cures it. This gives adequate temporary adhesion to hold the assembly together during handling in the final curing oven.

Getting correct temperature readings of the cement line during the complete processing cycle is closely associated with cement-heating method. Experience showed it was more important to measure cement line than oven temperature. In experimental work these temperatures were measured by thermocouples inserted between lining and shoe. Necessity of measuring temperatures this way, with a recording potentiometer, was forcefully brought to light in early development work.

Many bonds failed for no apparent reason, except that the cement appeared to be undercured. Yet all ovens, according to their own temperature recording systems, were set at correct curing temperatures.

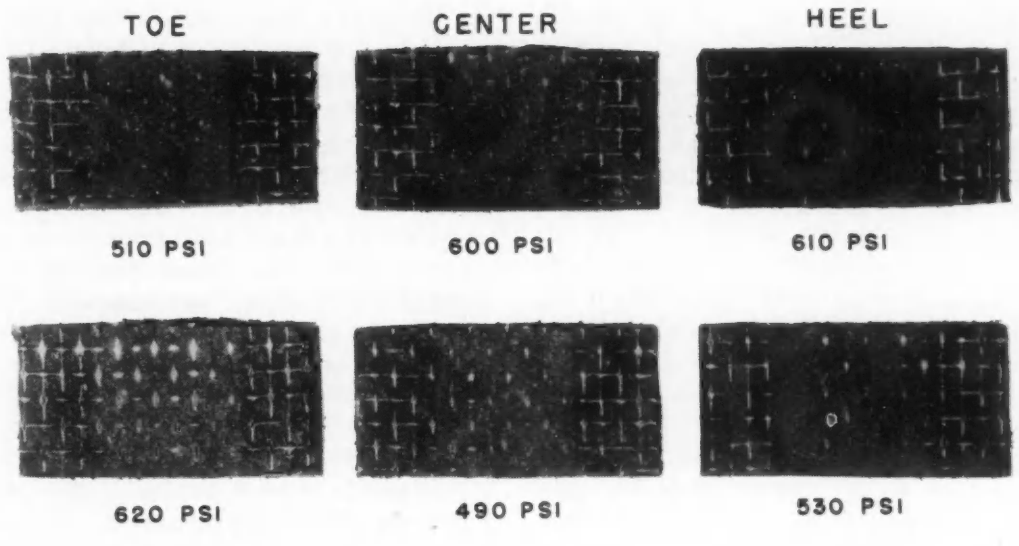
To find the cause of these failures, a dummy shoe and lining assembly, with a thermocouple inserted, were placed in the ovens. Temperatures recorded during this test showed that cement line temperatures were considerably below specification in all ovens as well as in the clamping mechanism. Raising oven temperatures produced acceptable bonds.

SHEAR TESTS DECEPTIVE

Improper curing also upset correlation of shear test and dynamometer test results. Under certain conditions, bonded linings found acceptable in both hot and cold shear tests, failed rapidly in the dynamometer test.

This lack of correlation probably

right, develop a total shear resistance of 13,200 lb in an assembly, and 6600 lb at higher temperatures



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stemmed from under-curing of the cement. When under-cured, the cement is tenaciously plastic. In the shear machine it'll hold up for a relatively short period during which pressure is applied. For this reason load readings at point of failure are fictitiously high. But in the dynamometer test, the load is applied cyclically and over a long period of time. In a bonded lining with under-cured cement under dynamometer test, cement flows until failure occurs.

Since the dynamometer test cycle is much too long for practical production testing, efforts are under way to develop a rapid shear test more nearly duplicating dynamometer test results. The shear test machine was modified to give cyclic loading, as shown in Fig. 1. Currently, a 45-sec cycle - 30-sec load and 15-sec unload - is being used. Brake lining samples of known characteristics are being tested at various shear pressures and cyclic-loaded to failure.

It's proposed that similar tests be conducted at different altitudes when more information is available. This is to find the most suitable standard test condition giving rapid results, reliably consistent with the dynamometer test. Development of such test is urgent for this process where temperature, pressure, and cleanliness conditions are so vital, where production is so rapid that a few hours output of poorly-bonded assemblies would be costly.

VIRTUE OF CLEANLINESS

The process also goes awry if the shoe's faying surface isn't clean. Cleaning here means complete removal of grease, oxide, dirt, and plating. Before it was known for sure that zinc plating must be removed, various cleaning methods were tried – chemical, grit blast, sand blast, hydroblast, and belt grinding.

Only the belt grinding method sufficiently removed the zinc from the shoe surface to produce an acceptable bond. Fig. 2 shows a pair of shoes that were hydroblasted. All the zinc wasn't removed, according to chemical analysis. Bond on these assemblies failed early in the dynamometer test. Zinc plating actually came off the shoe on the left and adhered to the lining.

Fig. 3 shows a pair of shoes that were belt ground. Chemical analysis indicated no zinc present. These assemblies passed all dynamometer tests, including salt spray aging, without indication of bond failure.

Another difficulty in this program - educational rather than productionwise - is making people understand the advantages of bonded linings. In some cases service men and laymen feel that rivets, being mechanical and visible, are a safer way to attach brake lining to the shoe than cementing. "Glueing," sometimes used, is derogatory to any bonding process.

BONDING VERSUS RIVETS

A true picture of the vastly superior strength of bonding over riveting is given in Fig. 4. Average shear strength of the riveted samples, at left, is about 300 psi, giving a total shear strength of the shoe-lining assembly of 1200 lb. Average shear strength of bonded brake lining, shown at right in Fig. 4, is about 600 psi. An 11-in. brake shoe has 22 sq in. of lining adhesion area, so that total shear strength of a bonded shoe-lining assembly is about 13,200 lb.

Shear strength of the bonded assembly at higher temperatures is about 6600 lb - five times greater than riveted lining strength. This is more than experimental promise.

Bonded lining processes have progressed to where volume production can be started. But new developments are being worked on to greatly decrease equipment, floor space, and manpower required in the factory. In the future we may see cement applied to the lining as an integral part of the lining plant's molding process. New ways of heating by high-frequency induction, now under investigation, will reduce bonding equipment to a minimum.

It's possible that bonded linings together with other mechanical improvements in the brake system will greatly reduce maintenance costs. Perhaps passenger cars will not need brake lining replacement or adjustment for the life of the vehicle.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

THRUST AUGMENTATION

Boosts Turbojet Engine Performance

BASED ON A PAPER* BY **Edward Woll**
Aircraft Gas Turbine Engineering Division
General Electric Co.

POOR climbing ability, reduced maneuverability at extremely high altitudes, and lower ratio of thrust to horsepower (0.6 as compared with 3 for propeller units) make it desirable to equip jet engines with some method of thrust augmentation (1) to shorten the take-off run for operation from small landing fields or carriers or when an extra heavy payload is carried and (2) to maintain good maneuverability at high altitudes.

Thrust can be augmented by increasing the airflow rate, the total temperature before the jet nozzle, or the pressure ratio across the jet nozzle.

The airflow rate can be increased by operating the engine at higher speed; cooling the inlet air to the engine through the use of a refrigerant; or by adding a more dense fluid to the air, for example, water injection at the compressor inlet or into the combustion chambers. Augmentation schemes also increase the jet velocity by increasing the pressure ratio across the jet nozzle. A reheat cycle makes it possible to increase the exhaust gas temperature above that normally permissible.

*Paper "Turbojet Engine Performance Characteristics with Reference to Methods of Augmentation" was presented at a meeting of the Southern California Section of the SAE, Los Angeles, Calif., Feb. 5, 1948.

Actually, augmentation is no solution for low propulsive efficiency, but it does offer a means for increasing thrust of powerplants now in use with little additional weight and complication, without resorting to extra large engine or additional engines for most applications, although the increase is gained at the expense of high specific liquid consumption.

METHODS OF AUGMENTATION

Schemes to augment thrust include the following:

1. Reheat cycle - commonly referred to as tailpipe burning - appears to be the most practical augmentation scheme. (See Fig. 1.) After expansion through the turbine, heat is added at constant pressure to the exhaust gas at a point downstream from the turbine wheel, yielding a temperature much higher than could be withstood by the stressed turbine blades. In this manner, it is possible to eject the gas at a much higher velocity than without reheat, increasing the thrust accordingly.

Fig. 2 shows the degree of augmentation at zero ram plotted against total specific fuel consumption (engine fuel and reheat burner fuel). With this method there is the lowest specific fuel consumption commensurate with high thrusts. The cycle can be used not only at take-off, but

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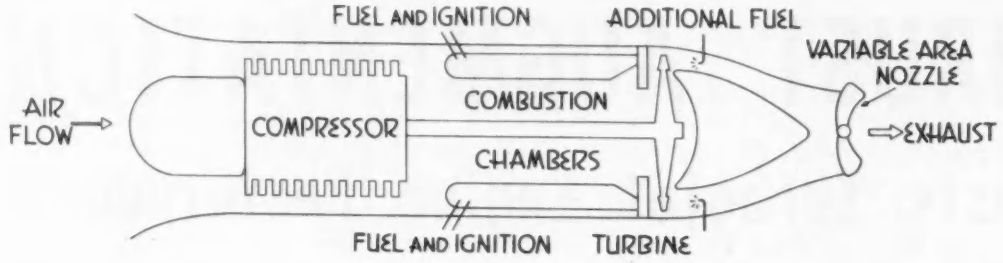
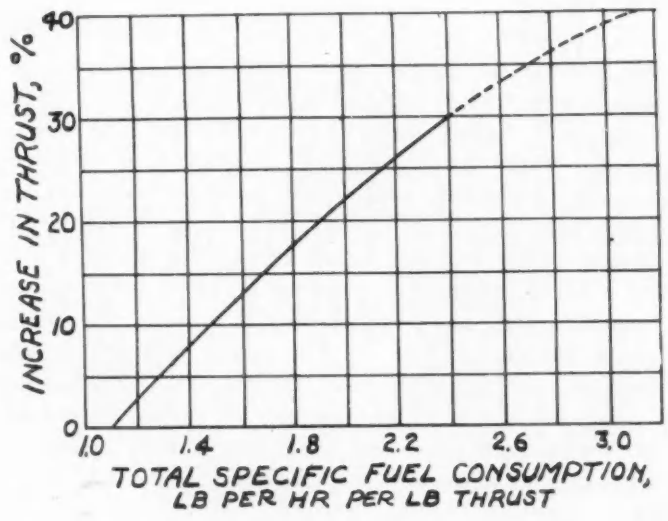


●Fig. 1 - Reheat cycle

also in flight as long as there is any fuel available. In addition, the net thrust is further increased at high plane speeds: at 600 mph the net thrust with tailpipe burning is nearly equal to the output of two turbojet engines operating in the normal manner. The reheat burner also makes it possible to maintain dry sea-level thrust up to higher altitudes. At 600 mph, sea-level thrust can be maintained up to about 30,000 ft. At lower speeds, sea-level thrust will be maintained to altitudes of not less than 20,000 ft. The reheat burner is somewhat analogous to the turbosupercharger in one respect: they both make it possible for an airplane to maintain a high degree of maneuverability and combat proficiency at high altitudes.

2. Bleed-burn cycle - Fig. 3 shows an axial-flow machine that has been modified to use this cycle. A small per cent of the total airflow is bled from the high-pressure part of the system. To maintain full engine speed and the same thrust, water is injected into the combustion chamber to replace the extracted air, which is led out through a separate duct to an auxiliary combustion chamber, thus bypassing the turbine. Here the air is heated to a temperature higher than would be permissible in the main engine. This hot gas is then discharged in a manner similar to that of the main stream (which is passing through the engine) but at a much higher velocity, thus increasing the overall thrust of the machine. The high liquid rate makes this scheme usable only for take-offs. A combination of water injection at the compressor inlet and the bleed-burn cycle has also been tried.

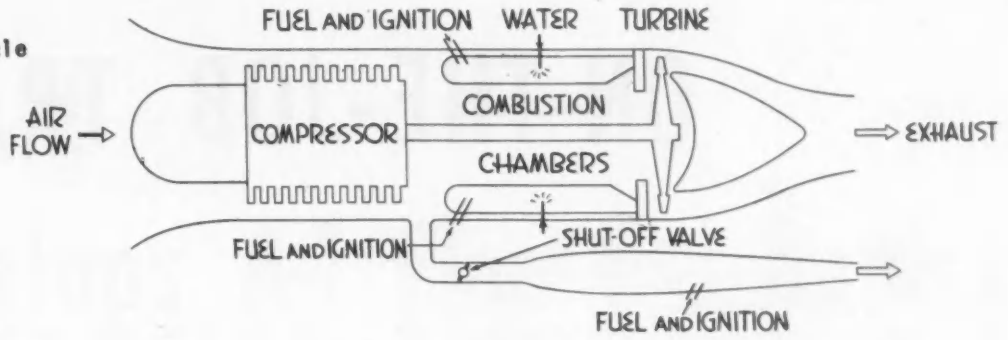


●Fig. 2 - Variation of total specific fuel consumption with thrust augmentation by means of reheat cycle - full rated engine speed

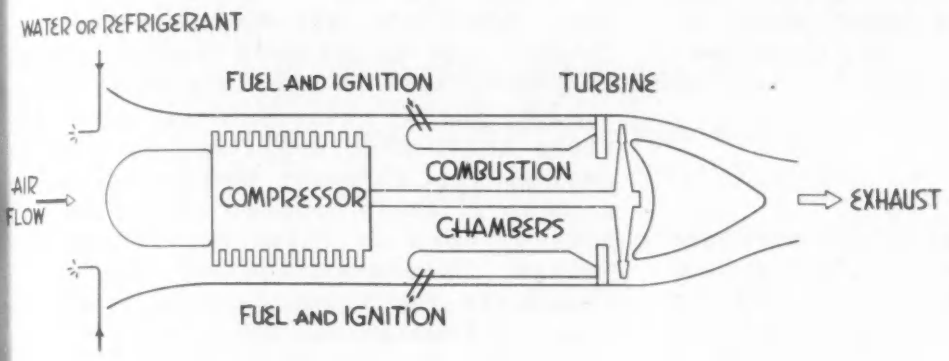
3. Water or refrigerants, such as ammonia and carbon dioxide, can be sprayed into the air either at the compressor inlet or upstream from the compressor (as shown in Fig. 4). Water can also be injected directly into the combustion chamber (as shown in Fig. 5).

Injecting water, for example, at the compressor inlet results in the following: (1) the incoming air is cooled (if the air is not saturated); (2) the air is cooled as it is being compressed; (3) the pressure across the jet nozzle increases; and (4) the mass of fluid handled by the machine is increased.

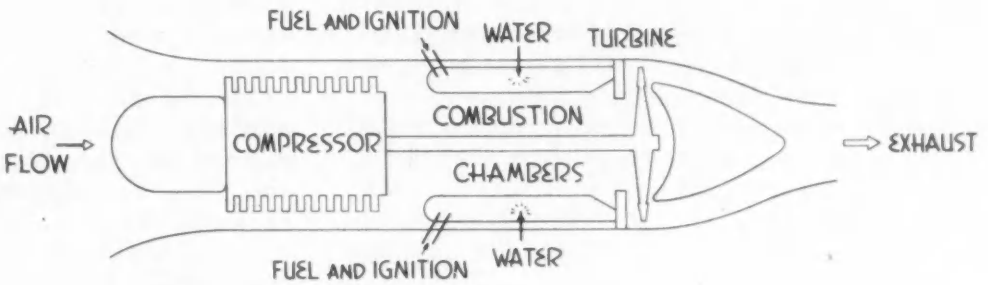
A 24% increase in thrust can be realized with water injection in a centrifugal machine, but the increase is obtained at a very high specific liquid consumption. Water-alcohol injection tests on an axial-flow compressor turbojet showed an increase of 12-16% in thrust. The higher value was obtained with water injection at the compressor inlet, the lower value



●Fig. 3 - Bleed-burn cycle



●Fig. 4 - Water or refrigerant injection at compressor inlet



●Fig. 5 - Water injection into combustion chambers

with water and alcohol injected into the combustion chambers.

There are, however, limitations to the increase in thrust obtainable through the use of water. At high water rates the exhaust gas temperature exceeds the normal value, but this can be corrected, within limits, through the use of a variable-area tailpipe nozzle. Continued use of hard water leaves a deposit on the walls of the air passages, causing a decrease in performance. Engines run in water tests did not stand up as well as those operating as nonaugmented engines for the same length of time. In view of the high liquid consumption, water injection will find use for take-offs only.

4. Overspeed is not an augmentation method in the strict sense of the word, but it is a simple means of increasing thrust for short periods by increasing the engine speed. Unfortunately, there is also an abnormally high exhaust temperature under these conditions. A 4-5% overspeed has been used successfully in high flight speed tests and in ground proof tests to establish a war emergency rating. Augmenting in this manner is not a recommended procedure except in an emergency, however, since overspeeding with overheating is a direct cause of shorter engine life.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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ON-THE-JOB TRAINING

THE severe shortage of trained and experienced mechanics that existed just after the war led to the establishment of a training program that has proved most successful in developing capable and responsible mechanics.

SELECTION

In general, the best candidates have been found among ex-servicemen that worked in various maintenance shops while in the armed forces. In some instances they had had additional civilian experience prior to the war, which has resulted in their being even better qualified.

Various tests are used to select the best men from those available.

The first group of tests, consisting of the visual acuity, depth perception, field of vision, driver's reaction, distance judgment, and Siebrecht attitude scale, are given to find out if the applicant is qualified to go out on road calls or to perform any other duty requiring that he drive.

Then the Scott IQ test is used to determine arithmetical reasoning, quickness of thinking, quickness and accuracy of judgment, clearness of perception, degree of comprehension, and ability to follow instructions.

The O'Connor block test is also given to determine ability to take things apart logically, to catalog the various constituent parts mentally, and to put them back together again in the shortest possible time.

The Purdue mechanical adaptability test is used to aid in identifying men and boys that are mechanically inclined and that, therefore, are most likely to succeed in jobs or training programs calling for mechanical interests and abilities.

After having satisfactorily passed the above test, each applicant undergoes a good general physical examination to determine if he is capable of handling the type of work to which he will be subjected. This examination is based on standards set forth by the Interstate Commerce Commission. The results are recorded on the following forms: personal and medical history, Keystone visual survey test, and the physician's certificate.

If all of these tests have been passed satisfactorily, the applicant is interviewed by the director of maintenance, who finally determines whether or not he is to be hired.

TRAINING PROGRAM

An on-the-job training program was developed that consists of practical training in each maintenance department in conjunction with regularly scheduled classroom instruction.

The on-the-job training extends over a period of 16 weeks. Apprentices spend two weeks in each of three different departments in the repair shop. Then they are assigned to productive jobs in the shop for 6-12 weeks, after which they are again assigned to three more departments for concentrated, on-the-job training.

This procedure is followed until each man completes the training in all departments, whereupon he is permanently assigned to the work for which he is best qualified. This is determined by his performance grades and the man evaluation records made out by the foreman and instructors in the various departments.

*Paper "Experience with Apprentice Mechanic Training" was presented at the SAE National Transportation Meeting, Philadelphia, April 1, 1948.

PROGRAM Develops A-1 Fleet Mechanics

BASED ON A PAPER* BY **A. Walter Neumann**
Assistant to Executive Vice-President
WILLETT CO.

Related technical instruction is taught through regularly scheduled weekly classroom sessions held throughout the year (except July and August). This material is presented by outside technical authorities or by skilled experts within the company. Every phase of the work is covered as completely as possible through lectures, movies, demonstrations, group performance, and examinations.

Whether or not an apprentice is qualified for graduation after having completed his training is determined by three performance grades, which are averaged for a final mark. These grades are:

1. A theoretical final examination covering all the related technical classroom instruction.
2. On-the-job training records, averaged for all departments.
3. A practical performance examination, which carries the greatest weight because it - more than anything else - determines if the man is able to get the job done on his own ability.

It consists of the trainee performing a complete preventive maintenance service inspection of the vehicle assigned to him. He notes what additional work is necessary to put the vehicle in A-1 condition, makes out a work order, and then does the work as indicated.

After the graduates have been selected, a graduation party is arranged, when diplomas are presented.

The correlation between the initial qualification tests (Scott IQ and Purdue mechanical adaptability tests) and performance grades is extremely good, indicating that these tests are definitely an aid to management in the selection of the right man for a job.

COSTS

The estimated annual cost to train an apprentice under this program is $252. This figure covers supervision, instruction, clerical work, equipment, labor, and graduation.

RESULTS

The results of this training program have been most pleasing. Out of 33 apprentices signed up, only five left after the first six months. This is only a 15% turnover. It was found that if a man remained for 30 days, he was very likely to be permanent.

As of Jan. 1, 1948, 21 men have graduated, and five more will graduate in June. Thus, from a total of 33 apprentices, 26 will have remained to graduate. So far, only one has left after graduating to take a job elsewhere.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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Ceramics May Serve

FOR TURBINE BLADES

BASED ON A PAPER* BY **R. F. Geller**
Chief, Porcelain and Pottery Section
National Bureau of Standards

CERTAIN porcelains may surpass metals as turbine blade materials in the temperature range 1500-1900 F — astounding as it may be to people accustomed to thinking of porcelains in terms of teacups.

Porcelains do not have the strength of metals at room temperature, but they do not lose so much strength as temperature climbs. Besides, porcelains are lighter. They have excellent resistance to creep below 1900 F, and they appear to become even more resistant to creep under prolonged loading.

The one questionable characteristic of porcelains is their ability to withstand thermal and mechanical shocks. This is a difficult property to measure. Shock-resistance tests for screening porcelains have been developed, but they are not sufficiently rigorous to supply the final answer.

Even though tests or service shows that porcelains do not have the shock resistance for turbine blade service, they are almost certain to replace metals in other high-temperature applications.

It is the ability of porcelains to retain much of their initial strength at elevated temperatures that puts them in competition with metals at temperatures above 1500 F. A number of metallic alloys have 100-hr stress rupture tensile strengths over 40,000 psi at 1200 F - a greater proved strength than any known ceramic has at any temperature – but the strength of metals decreases rapidly above 1200 F. Yet some porcelains have sustained tensile stresses as high as 17,000 psi at 1800 F for periods exceeding 100 hr.

The low density of porcelains adds to their strength advantage. Since stress is directly proportional to density, a porcelain blade having a specific gravity of 3.0 and a tensile strength of 17,000 psi is the equivalent in strength of a metal with a specific gravity of 8.3 and a strength of 47,000 psi. And at that temperature even the best alloy probably has a 100-hr stress rupture value of less than 12,000 psi.

Fig. 1 gives an idea of how strong porcelain can be in compression. Commercial all-crystallive porcelain rods 0.5 in. in diameter and 1 in. long were crushed between 0.5-in.-thick blocks of cold-rolled steel. The porcelain indented both steel blocks and, at the moment of failure, was under a compressive stress of 332,000 psi.

Some 330 specimens were broken in compression between steel blocks. They represented four trial commercial porcelains and 59 compositions developed by the National Bureau of Standards. About 55% of the specimens showed compressive

CONTINUED ON PAGE 48

*Paper "Ceramic Bodies for Turbojet Blades," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1948.

in Turbines and Jets

FOR INSTRUMENTS

BASED ON A PAPER** BY **W. N. Harrison**

Chief, Enameled Metals Section
National Bureau of Standards

APPLYING a ceramic coating to molybdenum to keep out oxygen makes it possible to use this heat-resistant metal for instruments that can withstand the high temperatures in jet and rocket powerplants. The trick is to apply the coating so that it really protects the metal.

If exposed to an oxidizing atmosphere, even at temperatures far below its 4750 F melting point, molybdenum may literally disappear. It oxidizes easily at high temperatures, and the oxide is volatile. Yet molybdenum presents a tantalizing combination of good qualities: unusually high melting point, considerable strength, ability to resist creep (in alloyed forms), and large potential supply.

Sealing out the oxygen with a protective ceramic coating is one good way to take advantage of these qualities. Even if the coating remains effective for only a short time, it will serve for some devices – such as instruments – where a short service life is acceptable.

Requirements for the ceramic are stiff. It must be highly refractory. It must adhere to molybdenum. It must have a coefficient of thermal expansion close to that of the metal in order to minimize residual stresses. And although it must be impervious to gases, it should allow gas absorbed in the metal to escape.

This last requirement means that the consistency of the coating during firing and subsequent use should permit sufficient flow to reseal the areas punctured by escaping gases.

To meet these requirements as closely as possible, the National Bureau of Standards has been applying the coating in three layers. The first is a base coat having a high content of glassy phase, the second a cover coat having little or no glassy phase, and the third another glassy-phase coat for sealing.

FRIT USED IN BASE COAT

The glassy phase is introduced in the form of a frit – a type of glass made by melting together the raw materials and pouring the molten mixture into water so that it will shatter in cooling and be easy to grind. For preliminary studies, NBS selected a frit having the composition SiO_2, 73.3%; B_2O_3, 9.1%; Al_2O_3, 6.6%; Na_2O, 6.7%; BaO, 2.1%; CaO, 0.8%; and KO, 0.7%.

Two cover-coat compositions are used, one principally calcined kaolin and the other zirconium oxide. Some raw kaolin is added to act as a bond and to maintain a workable consistency of the water suspension used to apply the coatings.

Zirconia is also added to the base coat in the ratio of 20 parts of zirconia to

**Paper "High-Temperature Ceramic Coatings for Molybdenum," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1948.

80 of frit. No frit is used in the cover coat.

Sandblasted molybdenum parts are dipped into or sprayed with a water suspension of the coating. After it has dried, the coating is fired in a furnace having a nonoxidizing atmosphere. NBS uses a small specially designed furnace which gives temperatures up to 2400-2550 F.

Total thickness of the three layers of coating ranges from 0.008 to 0.030 in. This is built up in several applications with separate firings. Experience shows that the base coat should be applied only 0.0015 to 0.0025 in. thick, to allow for escape of gases. Subsequent coats are added in thicker layers and, for best finish, fired at a temperature about 100 F lower than that used for the first coat.

TUBES TRIED IN RAMJETS

Service tests have shown the value of ceramic-coated molybdenum pitot tubes for ramjet use. Of 25 tubes tried out in ramjets attached to the wings of aircraft, two were returned for observation. Neither tube had failed in service, except for breaks in the uncoated zone near the end welded to a steel tube operating at relatively low temperatures.

One tube gave 15 min of service in a blast of gas at a computed temperature of 3000 F before it broke near the weld. In the hot zone, there were many areas where the outer layers of the coating had flaked off, but microscopic examination showed that a thin coating still remained. The metal was in good condition with almost no evidence of oxidation.

The other tube served 45 min and developed serious damage at only two spots. One spot was at the tip, which – unlike the first tube – had not been reinforced with extra coating, and considerable oxidation occurred. At a point near the center of the curved part of the tube, the coating failed, and oxidation had halved the thickness of the tube wall. The failure was credited to damage done to the coating during installation.

Since pitot tubes for ramjets need last only 5 min and are considered expendable, these results indicate that ceramic-coated molybdenum has adequate service life. If tantalum and tungsten can also be protected by ceramic coatings – and work is in progress on the problem – combinations of two of the three metals may be useful as thermocouples.

At lower temperatures ceramic-coated molybdenum sheet has shown much longer life. Specimens exposed to air at 1650 F showed no decrease in thickness even after 70 hr. An uncoated specimen exposed at the same temperature was reduced from its original thickness of 0.040 in. to about half that thickness within ½ hr.

A series of other tests indicates that ceramic coating gives important insulation effects. Coated specimens were exposed to a strongly oxidizing flame from an oxy-gas welding torch. Temperature of the hottest part of the specimen was determined with an optical pyrometer, the emissivity of the coating being taken as 0.50. Surface temperature was first brought to 1800 F and held for 5 min, then raised to 2200 F for 5 min, and raised by 400 F increments to 3400 F. Thermocouples embedded in the molybdenum on the reverse side, opposite the hottest area, registered from 360 to nearly 900 F lower than the surface temperatures. The greatest differentials were at the highest temperatures.

No loss in thickness was noted for any of the coated specimens. When the tests were repeated with temperatures held for ½ hr instead of 5 min, the 3400 F treatment brought some deterioration of the coating at the hottest area. Of course, the 3400 F recording was actual surface temperature, and later tests showed that gas temperatures may be on the order of 1000 F above surface temperatures.

Ceramics for Blades, Jets

CONTINUED FROM PAGE 46

strengths over 200,000 psi.

For 24 specimens broken in transverse bending tests, the modulus of rupture ranged from 13,000 to 46,000 psi and averaged 25,000 psi. The modulus of elasticity ranged from 19 to 39 million and averaged 27 million psi.

Under NACA sponsorship, NBS has secured

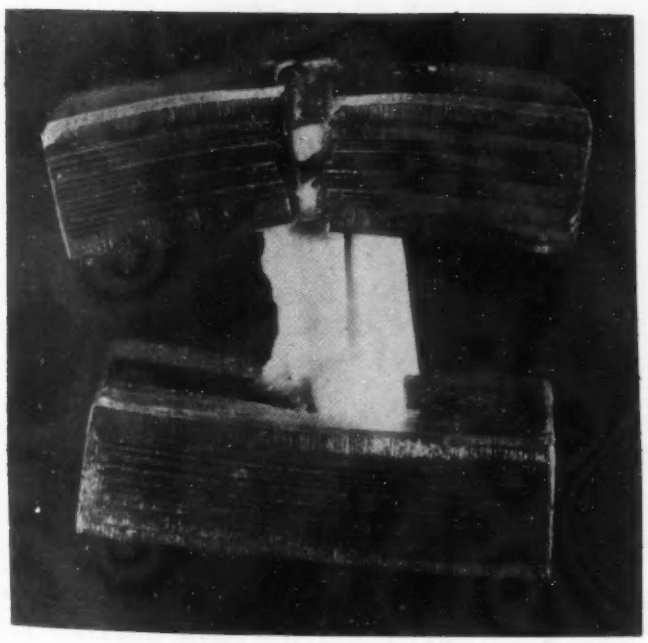
some encouraging data on tensile strength of eight 80%-zirconia porcelains at high temperatures. Tests generally showed strengths in tension up to 18,000 psi at 1800 F, and 15,000 psi at 1900 F. Above 1900 F, strengths drop off rapidly to an average of about 5000 psi at from 2000 to 2200 F.

Maximum observed creep rates for all the compositions tested ranged from about 0.0001 to 0.0002% per hr at 1700 F for the range of stresses used; from 0.0002 to 0.0008% per hr at 1800 F and 16,000 psi stress; and from 0.0003 to 0.0004% per hr at 1900 F and 10,000 psi stress. Above 1900 F, resistance to creep decreases rapidly. With one porcelain considered particularly resistant to creep, the rate of creep caused by a 6000-psi stress at 2050 F was more than 10 times the rate at 1800 F.

NBS evidence indicates that prolonged temperature treatments increase strength and creep-resistance of refractory porcelains. A particular porcelain does not have a characteristic strength at rupture or a characteristic creep behavior. Instead, creep rate may be diminished to a third or a fourth of the initial value during the course of a prolonged stress-temperature testing.

Although excessive creep precludes the use of current porcelains above 1900 F, there exist other compositions which may have better creep and strength characteristics. When fabrication problems are solved, these other compositions will be tested.

To screen porcelains for resistance to thermal shock, bar specimens simulating blades were subjected to a furnace tem perature of 1700 F for 30 min and then removed quickly to the air blast from a blower. After 15 min in the blast, they were returned to the furnace. Specimens of three commercial compositions and of two NBS compositions withstood 10 cycles of this treatment without any measurable impairment of their transverse strength at room temperature.



• Fig. 1 - Penetration and rupture of 1/2-in. thick cold-rolled steel block by 1/2-in. diameter specimen of commercial refractory porcelain during compression test

LABS STUDY SHOCK

In the present state of knowledge, this is the only kind of evaluation available for thermal shock resistance. It is known that resistance depends on several closely interrelated physical properties, but there is no generally accepted formula establishing the relative importance of the properties.

In general, resistance to injury due to thermal shock is increased by increase in strength, by decrease in modulus of elasticity and coefficient of thermal expansion, by elimination of irregular dilations resulting from phase changes, and by increase in thermal conductivity.

On the theory that small additions of a metal would increase the thermal conductivity of a ceramic, several laboratories are doing work on hybrid compositions of ceramic oxides with various metallic additions. Beryllium oxide – unique because it has both high electrical and high thermal conductivity – is being used in large quantities in a number of the NBS porcelains.

(Complete papers on which these articles are based are available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Designing

EXCERPTS FROM A PAPER* BY

K. L. Raymond

Engineering Division

GMC Truck & Coach Division

General Motors Corp.

DESPITE the record breaking 1,813,000 miles of bus operation with 30,200 buses in operation in 1946, bus fires reported by the Interstate Commerce Commission hit a four-year low. Only one accidental death for each 500 million miles of travel was reported that year.

Collisions, overturns, and ditched buses continue to dominate the list of fire hazards, accounting for about one-fifth of all reported.

The Bureau of Motor Carriers of the ICC is doing excellent work in studying road accidents and publishing these findings. Several times a year manufacturers of buses meet with ICC engineers to discuss design changes in the interest of increased safety on the nation's highways and city streets.

Greatest danger in accidents involving colliding, overturned, and ditched buses is ensuing fire around the fuel tank and in the engine area.

The SAE has been requested to develop specifications for collision resistant tanks calculated to reduce fire hazards. This project is expected to lead to performance specifications for bus tanks.

Bus fuel tanks are generally located in the midsection of the vehicle, affording a cushioning effect in case of collision at either end because the frame members absorb the shock protecting the tank from impact.

Of welded metal construction and with baffles, and supported to distribute shock loads without fracture, current practice is to design inlet, outlet, and other fittings on the top surface of the tank to protect them from stones and road projections.

Further protection is afforded by the Vent-alarm, a device which gives an audible signal when the fuel tank is almost full to prevent accidental spillage due to overflow.

Automatic valves are used on fuel filler hoses to shut off flow of fuel when the tank reaches full level. This is an added precaution against accidental fire.

FUEL LEAKS WORST OFFENDER

Faulty fittings resulting in fuel leaking on exhaust manifolds, pipe, or some inadvertently bared electrical connection are the chief causes of fuel system fires.

Today, fittings are being so located as to minimize this risk. Flexible lines are also installed between engines and structures to lessen the hazard of loose fittings and breaks in the line due to fatigue.

Fuel line fires showed a decrease in

*Paper "Providing Safe Transportation in Buses" was presented at the SAE National Transportation Meeting, Philadelphia, March 30, 1948.

SAFER Buses

1946 as compared with the previous year, but fires traced to bad wiring have shown a slight gain. This indicates that greater care must be exercized in improved maintenance as well as the use of better insulation and installation of the wiring system of buses.

Flame proof asbestos insulation, instead of impregnated cotton coatings for wiring in the engine area will resist burning and spreading fire.

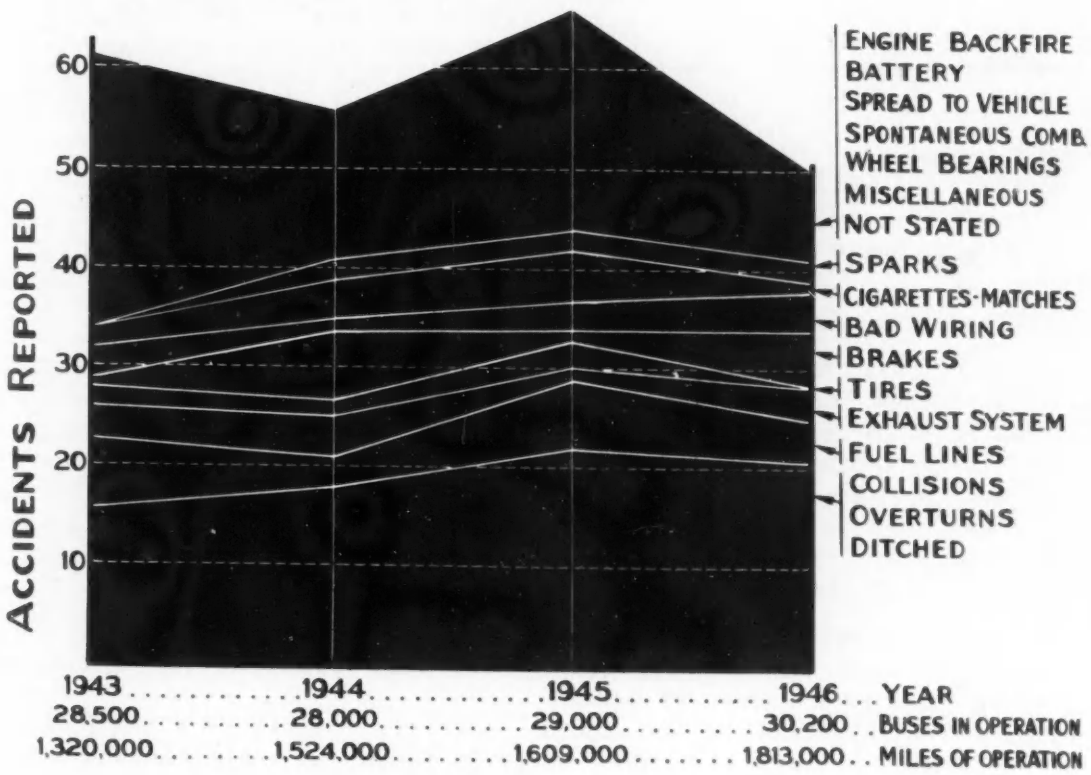
Bus wiring should be properly fused to prevent damage to electrical equipment and wiring in case of overload on the system. This also protects against fire breaking out within the electrical equipment itself.

Fire caused by overheating brakes continues to be a problem in view of the increase in accidents attributed to this source by the ICC studies.

Brakes have been known to develop temperatures as high as 1400 to 1500 F on the braking surface of drums during long applications at high vehicle speeds. This could be caused by long steep grades, or by dragging brakes.

At these temperatures it is not difficult to visualize oil and grease films in these areas reaching a flash point. This phase of the problem of fire hazards in buses is one which only the trained and

CAUSES OF BUS FIRES



1943	1944	1945	1946	YEAR
28,500	28,000	29,000	30,200	BUSES IN OPERATION
1,320,000	1,524,000	1,609,000	1,813,000	MILES OF OPERATION

●Decline in fires in buses in 1946 under 1945 drops under ICC reports for 1944 and 1943

careful driver can solve. Properly maintained brakes will not drag.

There is controversy in respect to fires being caused by overheated tires, but it is probable that tires at temperatures of from 300 to 400F could be ignited by an outside source. The tire at that heat would support combustion.

CONSERVATION AIDED SAFETY

Wartime conservation recommendations not only saved rubber when observed by drivers, but they tended to reduce accidents caused by tire failure.

Combustion type bus heaters to augment engine heat in cold weather are usually protected by automatic safety devices. These thermostatic controls, time delay switches, temperature control switches, and thermo-switches located inside the heater compartments, completely shut down the heaters in cases of emergency.

A great deal of investigation of methods to fireproof wooden bus floors is continuing. Paint type coatings, silicates, synthetics and synthetic laminates, and fiberglas are tested as soon as announced by suppliers.

Deadeners are frequently made of basic materials which support combustion, and are to be used as far from hot spots as possible. Metal bonded to wood simply tends to transfer heat caused by fire over a larger area. Much work lies ahead in solving this safety problem.

The primary causes of accidents, including fires, is human negligence or ignorance. Safe driving and preventive maintenance will reduce death and injury.

In a small way, we as manufacturers, can help with designs which will reduce the effects of negligence in operation and maintenance. We are trying to do that.

(Complete paper on which this article is based is available from the SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

Our Printers' Strike Goes On . . .

SAE QUARTERLY TRANSACTIONS, due April 20, will be in the mail near the end of June. . . . The July QT, due July 20, should reach readers about a month late.

Caught with one-quarter of its type set when the strike broke, arrangements for printing QT elsewhere were delayed from day to day, then week to week, hoping for a settlement of the printers' strike in Philadelphia (where SAE publications are printed) . . . Finally we gave up waiting. . . Found facilities elsewhere for setting type and producing in normal way at no increase in cost. . . .facilities which are not capable of meeting SAE Journal requirements of speed, time, and complexity at reasonable cost.

That's why QT will be set in normal type while SAE Journal continues to come in Vari-type. . . .and will continue in Vari-type through its July issue, at least.

Return to typesetting SAE Journal editorial pages, it was decided, would push too high the costs of production, already running more than 20% above normal.

Aid to Reliable Fuel Rating Emerges from CRC Test Work

Based on CRC report prepared by
Donald B. Brooks & Robetta B. Cleaton
National Bureau of Standards

FROM analysis of 18,957 ratings of 415 motor, aviation, and diesel fuel samples, the Coordinating Fuel Research Committee developed statistical tools with which petroleum and automotive engineers can predict probable accuracy of fuel-sample ratings. Easy-to-use charts, prepared from these data on current rating precision, measure a fuel's suitability for a given need based on a few sample ratings.

Fig. 1 is the story in a nutshell of Motor and Research rating reliability of motor fuel. It tells, for example, how far away from the true value the average of four ratings on an unfamiliar fuel is likely to be.

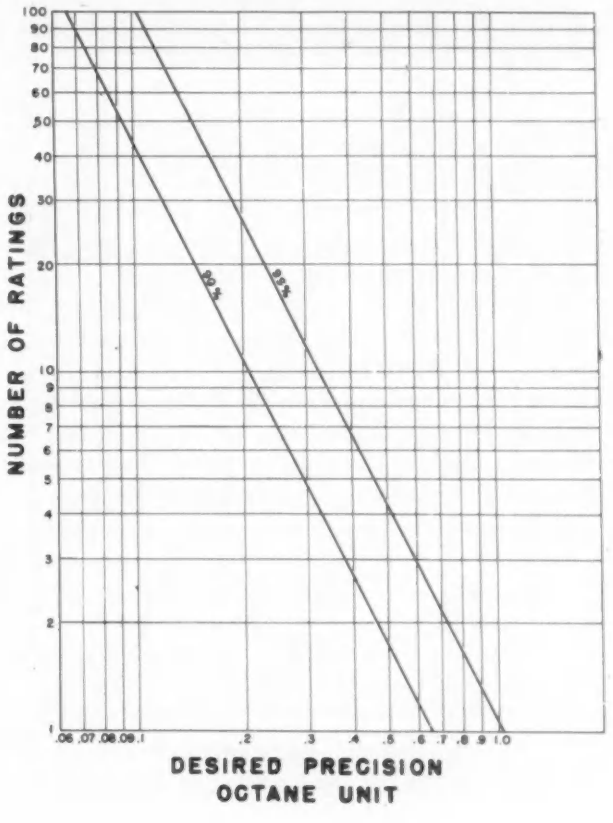
The lower line shows that with four samples, there's a 90% probability of being within one-third octane value of the truth. If you won't settle for 9 out of 10, the upper line shows you have 99 chances out of 100 of being within one-half octane unit of true value. Doubling the precision-scale values with the lower curve tells you there's one chance in a thousand your true value will deviate further from your average than the amount on the doubled scale. For this case involving four samples, it's two-thirds of an octane unit.

Laboratories with rating precision different from the 0.4 average octane-unit variation found in CFR survey can adapt Fig. 1 to their use. If your laboratory works to a precision nearer to 0.2 octane unit, divide the values on the scale by two. For precision nearer 0.6 increase them by 50%. But if you re around 0.8, it might be better to forget the whole thing.

Fig. 2 is the 90% probability curve for aviation fuels rated by the F-3 method. Here the data have been converted to AN performance numbers because of octane numbers above 100. In this performance scale 70 equals 88 octane number, 100 is 100 octane number, and 115 is equivalent to iso-octane plus 1/2 ml tetraethyl lead per gal.

This is a typical situation where Fig. 2 would be handy: Suppose you received a shipment of aviation gasoline for an operation requiring at least 130 perform-

● Fig. 1 - Probability curves on precision of motor fuel ratings by Research and Motor Methods



ance number. An F-3 rating gives you a 133 performance number for the fuel. Is it safe to use?

Fig. 2 shows that once in ten times a single rating may err by 3%, or 3.9 performance numbers in this case. On the basis of one test it wouldn't be safe to use the fuel.

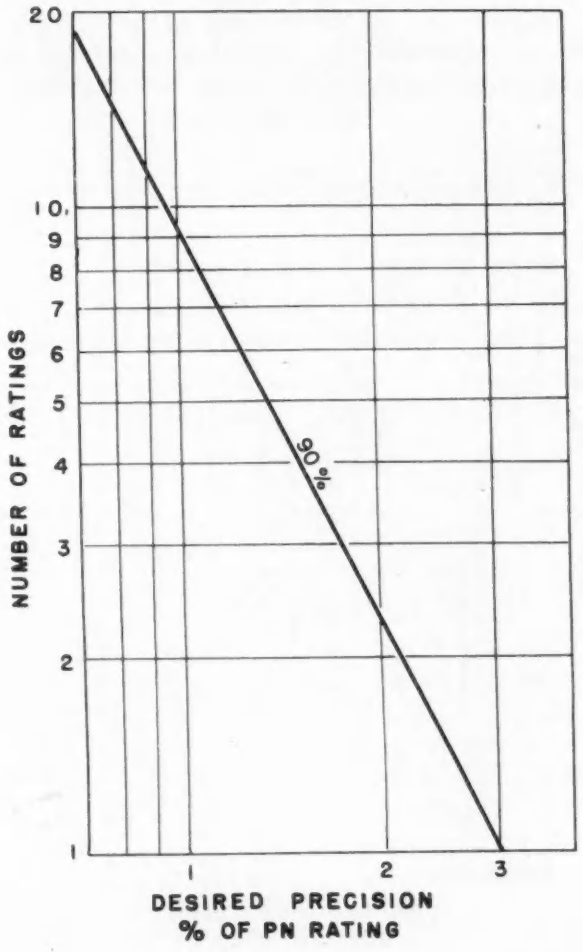
But if one or two additional independent ratings produce an average no lower than 133, the probability curve says there's a nine to one chance this fuel will meet your requirements.

The 90% and 99% probability curves in Fig. 3 for diesel fuels were computed for a 1946 standard deviation of 1.39 cetane number. This chart should hold for at least several years. It's used in the same way as the motor fuel and aviation gasoline probability curves.

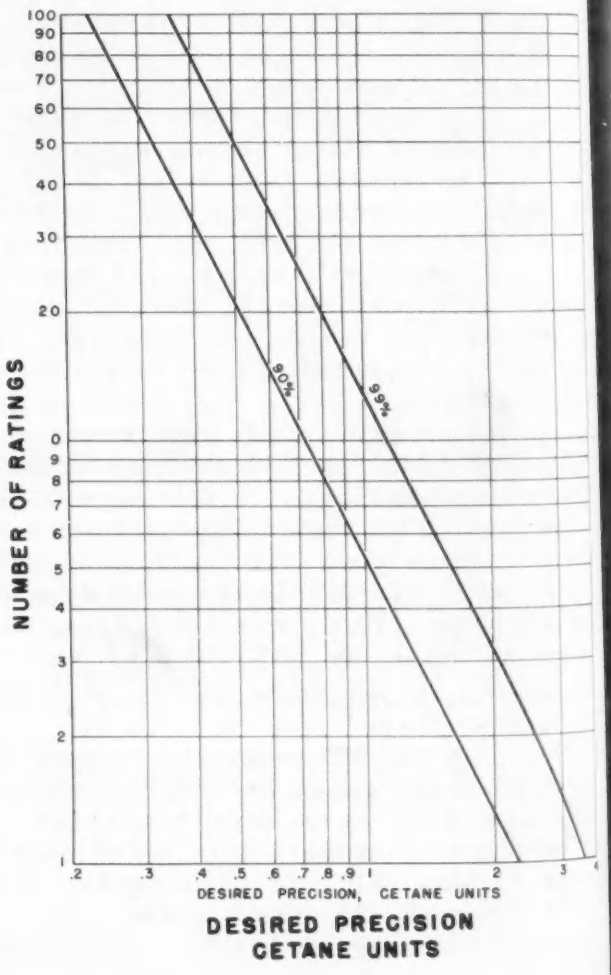
Take the case of a test laboratory that needs at least a 50 cetane number fuel. It gets an F-5 rating of 52 cetane number on a new shipment. Should the fuel be used in the engines requiring a minimum fuel cetane number of 50? No, says Fig. 3. Once in 10 times the rating error will exceed 2.3 cetane number and once in 100 times it will be greater than 3.6. But if two more ratings don't lower the average, Fig. 3 gives reasonable assurance that the fuel is at least 50 cetane number.

(Report from which this article is digested is "The Precision of Fuel Rating, 1942-1946," of the Exchange Groups, CRC Coordinating Fuel Research Committee.)

● Fig. 2 - This probability curve shows the number of F-3 aviation-fuel ratings required to yield an average having the desired precision



● Fig. 3 - With a given number of diesel fuel ratings, an engineer can determine from these curves how much above minimum acceptable quality results must be to insure getting that quality



Meeting Stresses Simplicity in Aircraft Operating Systems

• LaMotte T. Cohu, speaker at the SAE National Aeronautic & Air Transport Meeting dinner, April 15, with Toastmaster A. T. Colwell and Metropolitan Section Chairman J. O. Charshafian, who was also chairman of the General Committee

CHIEF problems of conventional aircraft today concern operating systems and accessories, sessions of the SAE National Aeronautic and Air Transport Meeting showed. Structural and aerodynamic problems are present now but secondary, while turbo-powered aircraft and rockets promise new combustion dilemmas.

The three-day gathering at the Hotel New Yorker in New York attracted more than 500 members and guests. Climax to 11 technical sessions was the Thursday dinner, at which H. B. Gibbons received the Wright Brothers Medal for his paper on sandwich-type construction. SAE President R. J. S. Pigott spoke briefly on the petroleum situation, emphasizing that recent gloomy estimates of the life of United States oil reserves overlooked the existence of undiscovered fields. This is not the time to start taking oil out of shale - that would cost too much steel - or to make oil out of coal, Pigott declared, but it is time to conserve through use of higher compression ratios, dual fuel injection, supercharging, and perhaps modified diesel cycles.

Principal dinner speaker was LaMotte T. Cohu, president of Trans World Airline. Reasons he gave why airlines lost more money in 1947 than ever before, although they carried more passengers and cargo were: too optimistic planning, lack of cost control, duplication of research, duplication of service, unwise passenger-rate reductions, high cost of introducing complex new airplanes, strikes, and wavering government policies.

The airlines' role in bettering the situation, Cohu said, is to boost the quality and dependability of their service, cooperate on research and facili-

ties, and insist on simplicity in aircraft designs.

Speakers and discussers at the technical sessions had already labeled lack of simplicity as the worst fault of aircraft operating systems and accessories. Agreeing that an airplane is only as good as its weakest system, designers and operators checked over powerplant-control, electrical, propeller-deicing, and instrumentation systems to see how they could be simplified and improved. Latest developments in automatic piloting devices were explained.

The blame for complexity was put on the airlines, for specifying automatic operation of so many units; on aircraft manufacturers, for intermingling systems and failing to seek the simplest arrangements; and on government agencies, for making needless rules.

Operators and manufacturers acknowledged that the airplane will always be a complex piece of equipment, but they spoke of simplicity as an increasingly important design goal. Five ways to approach the goal emerged: The airlines can eliminate some of their many specifications for automaticity. All airlines ordering a particular aircraft can standardize on operating systems. Manufacturers can build mock-ups of systems to ensure that they fit in space allowed and to permit complete functional testing so that design will not be complicated by later corrections. Consideration of airline operating problems can be given during design for military use. Engineers

● President R.J.S. Pigott, left, with L. T. Miller, vice-president for Aircraft Powerplant Engineering and member of the General Committee

● W.J. Blanchard, Aircraft Powerplant Meetings chairman, with W.C. Lawrence, Air Transport Meetings chairman. Both were members of the General Committee as were Vice-president W.W. Davies, H.D. Hoekstra, and Dr. A. L. Klein

with airline experience can be employed for designing systems.

Getting down to specific cases, engineers debated first the merits of electric, electronic, hydraulic, and pneumatic powerplant controls versus mechanical powerplant controls.

Proponents of nonmechanical controls stressed their simplicity and ease of development. And an installation engineer presented results of a survey showing that nonmechanical controls are being developed and that aircraft manufacturers are ready to try them, but that such controls are not being used because the customers aren't interested.

In answer, airline representatives admitted that engineering inertia might be part of the reason for their lack of interest, but they pointed out that they are using nonmechanical controls for some systems less critical than the powerplant. Besides, electric controls used on the propeller, they claimed, have been troublesome. Let the controls designers establish proof of the reliability of their nonmechanical controls, then use some salesmanship, was the airline attitude.

Rather than use current electric or electronic controls - which make one primary system, the powerplant, dependent on another primary system, the electrical system - the airlines prefer to put up with the troubles they experience with mechanical systems, a maintenance expert said. A CAA spokesman reported that typical troubles are loose pulleys, loose or broken cables, bracket failures, and maladjustment of rigging. Failures in powerplant-control systems account for 14% of all failures noted in CAA Mechanical Interruption in Flight Reports.

The maintenance expert explained that many of these troubles are due to vibration. Anything that reduces vibration or isolates control system components will help. Cables loosen or break because they elongate with operating loads, because pulley brackets bend, and because the airplane structure deflects, he said. Designers were told they could alleviate misalignment of rigging by simplifying the rigging job for the mechanic: they could jig locate all brackets and provide locating holes in pulleys and brackets.

Despite the airlines' present preference for mechanical controls, designers of controls for turbojets are proceeding to design electric, electronic, and hydraulic-mechanical systems. The four turbojet controls now evolved were described by authors and discussers. Features of the newest electronic control are a full-floating governor employing derivative anticipation to determine electronically future values of both speed and temperature from preceding rates of changes, and single-throttle-lever control of the engine.

Control systems for turboprops are not so well developed as those for turbojets,

• John G. Lee, assistant director of research, United Aircraft Corp. and member of Wright Brothers Medal Board of Award, presenting the 1947 award to Henry Bendel Gibbons, Chance Vought Division, for his paper "Experiences of an Aircraft Manufacturer with Sandwich Material," presented at the 1947 SAE Annual Meeting

but designers know what functions their systems must perform. According to one designer, the system must enable the pilot to select a desired value of thrust for each flight condition, yet restrain him from demanding a value of propeller thrust which results in excessive gearbox torque, turbine blade temperature, or rotational speed or from demanding an inefficient torque-speed combination.

It was predicted that a turbojet control, with propeller control system superimposed, will probably be used to do the job for turboprops.

Aircraft electrical systems can be seriously damaged by lightning, the Lightning and Transients Research Institute has found. A representative reported a case where lightning followed the antenna lead inside the ship and flashed to the ground inside the transmitter antenna changeover relay, cutting off communications. In another case, grounding was completed outside the equipment, setting the radio compartment on fire. SAE members were invited to participate in a symposium planned by the Institute for next fall, covering prevention of such damage and other topics relating to the effects of lightning on aircraft and personnel.

HIGH-ALTITUDE HEAT

High-altitude flying is bringing new troubles with electrical equipment. Oddly enough, cooling is the major problem at high altitudes, an electrical engineer reported. Although atmospheric temperatures are lower, the air density is so low that the air mass can't carry away enough of the heat. For high-altitude use, generators will have to be redesigned with more open construction around the field poles and armatures.

A comparison of propeller performance with ice and with heated-air deicing brought out that, in designing heated-air systems for propellers, the aim should be to minimize exit nozzle area and to achieve an aerodynamically clean internal flow line and nozzle. With a well-designed anti-icing system, there is about a 1% loss in aerodynamic efficiency. Without the system, the loss is about 3% for a moderately iced propeller in cruise or climb. In steep climb, iced blades may be stalled, resulting in a 15% or greater loss in efficiency.

Outstanding difficulty with instrumentation is that the instrument panel presents too much information to the pilot, sessions showed. No human being is capable of covering all the instruments under certain tough flying conditions.

AUTOMATIC PILOTS DISCUSSED

A symposium on automatic pilots highlighted the performance of current models. They can handle an airplane safely in any flyable weather. They can maintain attitude, magnetic heading, altitude, a navigational track, the approach to the runway, and airspeed. Both the A-12 and the PB-10 pilots can establish coordinated turns.

Although airline spokesmen reported that the improved electronic autopilots are giving excellent service, they believe that the airframe manufacturer and the autopilot manufacturer could cooperate to devise a better installation for the circuits that connect the unit to the plane components.

The Aero Medical Laboratory is seeking better ways of presenting instrument data to the pilot. From a survey of pilot's errors in reading instruments, the Laboratory found that most errors are due to faulty interpretation, rather than to difficulties with legibility or acuity. The Lab's psychologists have found that both check and qualitative reading of an array of instruments is facilitated if the dials are arranged in a rectangular bank with all pointers at 9 o'clock under normal conditions.

Reason why structural problems are no longer prime troubles are that more thorough testing is uncovering structural weaknesses and pointing the way to solutions, and that new structural analyses are making design surer.

Management has found that a good testing program is the best guarantee that the stress-analysis assumptions, structural compromises, changes, and substitutions have been accounted for properly. Describing the functioning of Martin's structural test department, two of its chief engineers told how their responsi-

bility begins with contract negotiations, extends throughout test set-up and performance, and ends only when the airplane receives final approval.

But don't go overboard on structural testing, engineers were advised during the discussion period. While its great contributions to the aircraft-building art should not be overlooked, said one specialist, engineers should try to unsell purchasers - particularly the military - on excessive testing, for the sake of economy and swifter release of aircraft.

Typical of new design methods available for structural designers is a series of charts presented by an NACA engineer for selecting the optimum proportions of longitudinally stiffened wing compression panels. These direct-reading charts were developed from test results covering a wide range of proportions, stiffener shapes, materials, and modes of failure. The charts are available for 24S-T and 75S-T panels with Y-section stiffeners and for 24S-T panels with Z-section stiffeners.

Another design tool discussed was a method of analyzing the dynamic loads on an aircraft structure. The trend toward greater structural flexibility and more rapid application of landing and flight loads in large fast airplanes makes it necessary to consider the inertia forces associated with elastic distortions. Two stress analysts presented their method of synthetizing the dynamic loads from the history of the exciting forces. They

Based on discussions and six papers presented at three Aircraft sessions, under chairmanship of G. L. BRYAN, R. H. DAVIES, and E. W. "POP" CLEVELAND; five papers presented at three Transport sessions, under chairmanship of K. R. FERGUSON, L. A. RODERT, and W. C. LAWRENCE; two papers presented at one Joint Transport and Aircraft session, under chairmanship of R. D. KELLY; and nine papers presented at four Powerplant sessions, under chairmanship of W. P. ENGLISH, M. G. BEARD, A. M. ROTHROCK, and F. C. MOCK... "What Price Structural Testing?" by S. A. GORDON and G. E. HOLBACK, Glenn L. Martin Co., "Design Charts for Longitudinally Stiffened Wing Compression Panels," by N. F. DOW, NACA; "Performance of Electrical and Radio Equipment at 40,000 Feet," by KARL MARTINEZ, Boeing Aircraft Co., "Design of Instrument Dials for Ease of Reading," by W. F. GRETHER, Aero Medical Laboratory, Wright Field; "Dynamic Loads in Airplane Structures," by E. S. JENKINS and D. P. C. PANCU, Consolidated Vultee Aircraft Corp., "European Landing Gear Developments," by H. G. CONWAY, British Messier, Ltd. ..."Simplicity as a Goal in the Design of Aircraft Systems," by L. R. KOEPNICK, Trans World Airline, "The Fallacy of Arbitrary Performance Regulations," by R. W. AYER and F. W. KOLK, American Airlines, Inc.; "Effect of Ice and Heated Air Deicing on Aerodynamic Performance of Propellers," by B. W. CORSON, JR., NACA, "Lightning Effects on Aircraft," by M. M. NEWMAN, Lightning and Transients Research Institute; "Some Experiences Pioneering Air Transportation in Peru," by B. H. YOUNG, Pan American Grace Airways, Inc. ... "The A-12 Gyropilot," by P. HALPERT, Sperry Gyroscope Co., Inc., "The PB-10 Automatic Pilot for Air Transport," by P. A. NOXON, Eclipse-Pioneer Division, Bendix Aviation Corp. ... "Factors Affecting the Selection of Propellants for Rocket-Powered Aircraft," by T. F. REINHARDT, Bell Aircraft Corp., "Design and Development of Rocket Powerplants for Aircraft," by A. K. HUSE, Reaction Motors, Inc.; "Ancestor Worship in Engine Control Design," by R. R. HIGGINBOTHAM, Republic Aviation Corp., "Survey of Aircraft Powerplant Installation Troubles in Scheduled Air Carrier Operations," by J. W. BAIRD, CAA, "Air Transport Maintenance and Engineering Aspects of Powerplant Controls," by H. W. NEVIN, JR., United Airlines, Inc., "Combustion in Moving Air," by F. R. CALDWELL, F. W. RUEGG, and L. O. OLSEN, National Bureau of Standards, "The Ideal Temperature Rise Due to Constant Pressure Combustion of Hydrocarbon Fuels," by N. A. HALL, University of Minnesota, and R. C. MULREADY, United Aircraft Corp.; "Jet Engine Controls," by A. T. COLWELL, Thompson Products, Inc., F. F. OFFNER, Offner Products Corp., and T. R. THOREN, Thompson Products, Inc., "Controls for Gas Turbine Propellers," by R. C. TRESEDER, Aeroproducts Division, GMC... All of these papers will appear in briefed form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.

calculate the distortions due to the loads by a classical linearized solution and determine the loads from the distortions.

Some engineers wondered if such dynamic-load-distribution assumptions and short-cut computations aren't a too-pat answer to their problems. They want test-flight backing of such work, before accepting it at face value.

OVERSEAS IDEAS AIRED

In their search for greater efficiency in aircraft design, engineers were treated to new weight-saving ideas in landing gear structures, including bogies and skids. A British engineer reported that with bogies, the fore and aft disposition of the wheels brings new troubles. For example, application of the brakes transfers too much weight to the front wheels, and, for the plane to turn on the ground, the nosewheel must provide an appreciable turning force.

British and French engineers have been debating the advisability of dispensing with landing gear. The British speaker favored skids, as a compromise. Skids save most of the expense of landing gear, yet they are lighter than conventional gear, he said.

Not all the new and unusual ideas in structural design are coming from manufacturers' engineers. Although he didn't recommend it as standard practice, an engineer for an airline pioneering transport in South America told about cutting the panel between the passenger door and the baggage door on a DC-2 and hanging it on a hinge so that pipe could be loaded for a remote oil drilling outfit in Peru.

Part 04B, Transport Category, of the C.A.R. was criticized as not expressing the ideas it was meant to express. Among the rules specifically attacked was the one which relates rate of climb required to make an airplane capable of crossing en route terrain with one engine inoperative, to the square of stalling speed with flaps in landing positions. According to two airline engineers, it would be more reasonable to require the airplane to clear the highest obstruction on the route by a certain distance and have, at the same time, a certain rate-of-climb kitty in case of rough air.

They feel that present rules penalize 2-engine craft, especially on field length, yet may be too lax with 6-engine aircraft. They would like to see the C.A.R. revised to provide equivalent safety for 2-, 4-, and 6-engine planes.

A C.A.B. man agreed that the C.A.R. are not perfect, but he pointed out that the C.A.R. can't please everyone. As an example of the differing opinions, he referred to the pilots' complaint that the rules are based on fair weather conditions and are inadequate for bad-weather operation. A Canadian engineer, noting that the C.A.R. are about to be adopted by ICAO, seconded the authors' plea for more flexibility in the rules so that they would be applicable to turbo-powered aircraft.

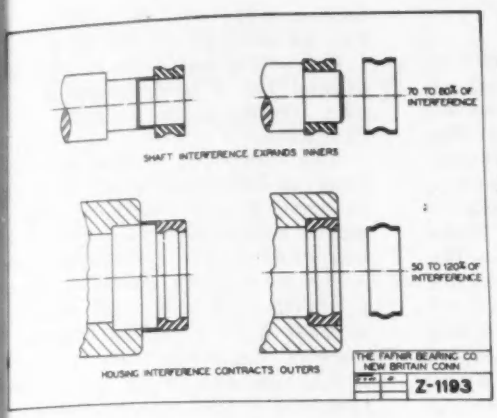
The new powerplants - turboprops, turbojets, and ramjets – are stimulating research on combustion and fuels, sessions disclosed. Current combustion research is directed toward obtaining basic design and performance data.

A paper by three NACA investigators noted that difficulties with combustion in moving air are minimized when the chamber can operate at high temperature ratio and low stream velocity. High temperature ratios permit the use of near-stoichiometric air-fuel ratios, stabilizing the flame. Low gas velocities aid the flame in reaching all the mixture.

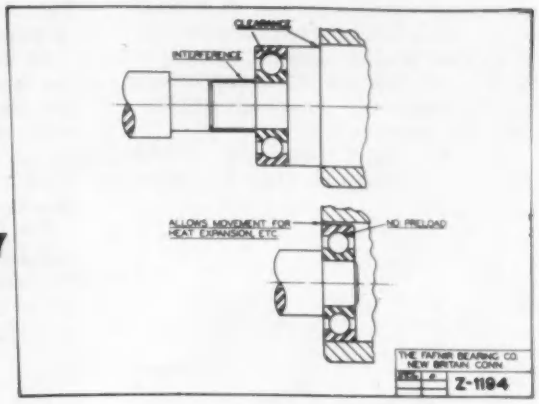
For the convenience of engineers working with ramjets, afterburning, and other constant-pressure-combustion cycles, two thermodynamicists presented a series of charts for determining the ideal temperature rise from hydrocarbon fuels. Two basic charts give temperature rise as a function of fuel-air ratio for several inlet temperatures ranging from 537 to 2000R.

As a rocket fuel, gasoline is only mediocre, a rocket expert reported. Liquid-propellant rockets are turning to aniline, alcohol, and hydrazine. A good rocket fuel was characterized as being made up of elements of low atomic weight and compounds of low molecular weight.

The simple jet-impingement-type injector has been found best for all liquid rocket propellants.



● Fig. 1 - How interference fits with mating parts affect bearings



● Fig. 2 - Housing clearance prevents outer ring distortion

Tells What To Consider In Selecting Bearings

Based on paper by

FAYETTE LEISTER

Fafnir Bearing Co.

ALWAYS pay attention to these two items when specifying ball bearings - the fit to mating parts and the "fixed and floating position" feature.

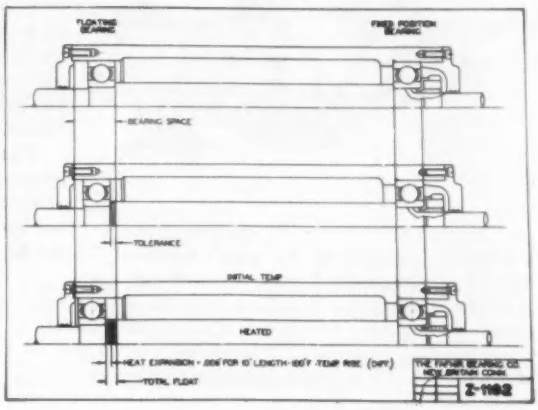
A press fit to the mating part securely fastens the rotating ring. The inner ring is press-fitted for a rotating shaft. In a loose pulley, for example, where the housing rotates about a stationary shaft, the outer ring is press-fitted. Effect of this on respective rings by expanding or contracting races is shown in Fig. 1.

Ball bearings usually are made with sufficient internal clearance for only one of the two press fits, not both. Regular production bearings, used with recommended shaft and housing fits, are satisfactory for this usual procedure. For other fits required, consult a bearing specialist.

Fig. 2 shows the situation with recommended fitting, with some exaggeration for clarity.

Housing clearance shown allows the outer ring to assume its proper longitudinal position in the housing, as determined by the shaft. This position may vary initially or after completion of assembly for several reasons.

Role of second basic ball-bearing consideration - fixed and floating position arrangement - is depicted in Fig. 3.



● Fig. 3 - Floating and fixed position arrangement in ball bearings compensates for tolerance and heat expansion, maintaining functional normalcy

In the top diagram is the designer's ideal assembly. But all parts, as their details show, have tolerances. In assembly these tolerances come into play as in the center illustration in Fig. 3. The floating bearing, properly fitted to the shaft and in the housing, has moved axially to compensate for these tolerances without affecting operation of the assembly. Were both bearings fixed, heavy axial loading would result in compensating for amount marked Tolerance.

This also might happen in operation: The shaft gets warmer than the housing and must lengthen axially under the temperature rise. The bottom diagram, Fig. 3, shows the fixed and floating arrangement makes allowance for this too. The floating bearing assumes a position two increments from the designer's ideal, yet functions perfectly. (Paper "Ball Bearings - Design and Application, was presented at SAE Cleveland Section, March 8, 1948.)

Production Engineering Functions at Buick

Digest of paper by

HARRY S. GOLDEN

Buick Motor Division, GMC

BUICK'S Engineering Department consists of the Design, Production, Engineering, and Long Range Designing Divisions and the usual experimental manufacture testing and laboratory activities.

The Production Engineering Division acts as liaison between Car Engineering and the Master Mechanics Department, Production, Purchasing, Inspection, and the Service Departments.

The production engineer determines whether the material specification shown on all drawings is in order, and whether limits specified conform with requirements necessary to assemble.

He also checks drawings for

possible manufacturing difficulties which his experience indicates might cause trouble. Discrepancies are reported to the design engineer or chief draftsman for correction.

An important function of the Production Engineering Division

is investigations of engineering changes requested by the factory in the interest of cost reduction, easier assembly, product improvement, inability to obtain specified materials, improved machines, or to use up material inadvertently cast or forged.

Primarily, these investigations seek to effect improved performance of the product. The designing engineer approves or rejects recommendations on the basis of these reports.

The Division also processes all changes regardless of point of origin. A change requested by the engineering division is a written report embodying all the information gleaned in the original investigation, and the model's point of change, servicing information, and disposition of any obsolete material.

Representatives from the Manufacturing, Inspection, Purchasing, Master Mechanics, Service and Engineering Departments make up the change committee which gives final approval to proposed changes.

Changes, whether approved or rejected, can be opened for further investigation if requested by any of the departments represented on the change committee.

The Production Engineering Division writes and distributes experimental and production releases and parts lists, and distributes blueprints and vandykes.

Because this division acts as a clearing house between the Engineering Department and the factory, it has charge of the company's specifications.

In determining alternate design the question often is settled on the basis of cost. These studies and reports are made by the Production Engineering Division, with the help of the Process, Standards and Cost Departments.

The Purchasing Department faces continual material shortages. The Production Engineering Division investigates all proposals of substituting other materials and obtains determination from the Engineering Division. This sometimes involves running tests, which the Division undertakes.

Engineering information books are written by the Production Engineering Department. These contain sequence of assembly operations, desired fits, proper torques for nuts, and point out possible trouble spots.

The division also supplies resident engineers for assembly plants. These men keep the plants fully informed about new assembly methods and equipment, and are responsible for the quality of the product.

Every day at least one car is picked for a 100% inspection by the Production Engineering Division.

The division works with the Traffic Department and carriers in improving methods of loading and tie down for rail and truck shipments. Test shipments are made with new models. This activity has saved the company several dollars per carload, and assures arrival in good condition.

All engineering questions involved in servicing automobiles are handled by the Production Engineering Division, which also supplies information for the preparation of service bulletins. (Paper "Functions of Production Engineering Department at Buick," was presented at SAE Annual Meeting, Jan. 13, 1948, Detroit. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

A-C Electrical System Advocated for Vehicles

Based on paper by

ALBERT D. GILCHRIST

Leece-Neville Co.

SPECIALIZED wide-speed-range, high-output vehicle electrical power systems are in demand as a result of increasingly greater use of mobile two-way radio. A rectified a-c system (with alternator, rectifier, and regulator system) satisfies this need and at the same time lasts longer and performs better than conventional d-c systems.

The alternator-rectifier system develops 60-amp rated output at much lower speed than the d-c system. Although the d-c system has a slightly lower cut-in speed, the alternator-rectifier system shows greater output over a much wider speed range. At engine idle speed, the new system produces double the output of the d-c system.

The higher-efficiency alternator makes possible design of machines with greater output for lower speeds than d-c generators, operating with the same temperature rise. The a-c generator provides a convenient source of power for heating and lighting loads. It places at the engineer's disposal any alternating-voltage value he wants.

An alternator lends itself to more uses because it can run in either rotation or use a delta connection to gain output currents 1.732 times present values. The same basic alternator may be used in both 6 and 12-v systems with only a change in rotor coil required by the voltage regulator.

Several notions have been considered for improving performance of the d-c generator and for adapting it to more exacting requirements of current vehicles; but they all produce improved features at sacrifices in others. For this reason the alternator-rectifier system was chosen as the best wide-speed-range, high-output source of a-c and d-c power for future vehicles. (Paper "An A-C Vehicle Generating System," was presented at SAE Washington Section, Dec. 9, 1947. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to member, 50¢ to nonmembers.)

Tells When It Pays To Retire A Truck

Based on paper by

JOEL DEAN

Columbia University

(This paper will be printed in full in SAE Quarterly Transactions)

THE time to replace the old vehicle is when it's more profitable to buy a new one. Cost projections - future costs - are the basis telling when that time has come. Knowledge of behavior of cost components is the foundation of these projections.

Behavior of costs with increased use is the key to determining savings that govern replacement. Fig. 1 illustrates the essence of practical replacement by graphical analysis.

It shows annual cost of a hypothetical $5000 truck on a given operation. Shape of actual curves differs widely among operators, depending, for example, on operating conditions, account classification, and preventive maintenance standards. These curves show economic factors that enter into the replacement decision. They are as follows:

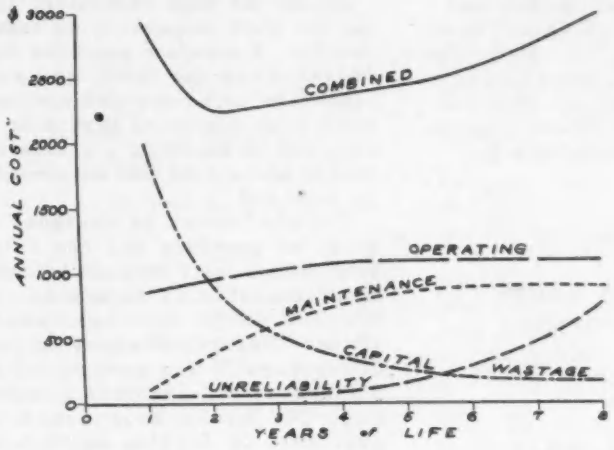
• The Capital Wastage Curve shows market-value depreciation based on expected decline in disposal value each year. It drops sharply at first, then falls off more gradually as the truck gets older.

• The Maintenance Cost Curve represents the increase in annual maintenance and repair expenses over most of the truck's life.

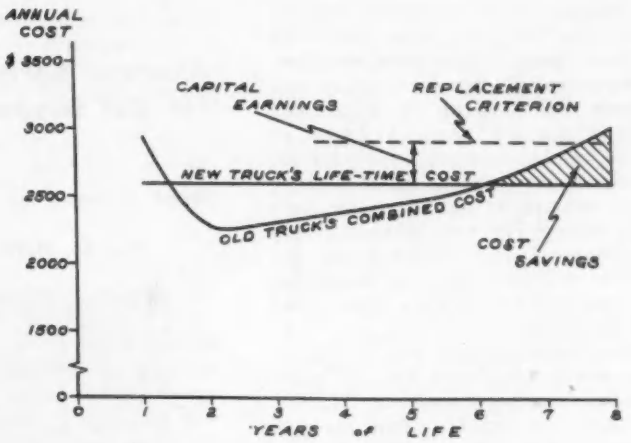
• The Operating Cost Curve includes the usual operating expenses, such as fuel, oil, and tires. It rises gradually at a declining rate.

• The Unreliability Cost Curve reflects an estimate of direct and indirect losses from increasing undependability, as from road breakdowns and idle time for repairs. It's presumed to rise gradually as the truck ages.

• The Combined Cost Curve of the old truck sums up the several component cost curves. It declines at first, reaches a low point, then rises when rising maintenance, operating and unreliability costs more than offset declining capital wastage costs.



• Fig. 1 - Annual costs of keeping the old truck additional years



• Fig. 2 - Comparing old-truck versus new-truck costs to determine savings from replacement.

The horizontal line in Fig. 2 is the average combined cost of the new truck. You calculate it by dividing total estimated cost of the new truck (excluding interest) throughout its expected useful life by the number of years of expected useful life.

Point of economic replacement is determined by prospective cost savings from replacement as a percentage of net capital expenditure needed to get these savings. Spread between the curve of combined old-truck costs and line of life-time new-truck average costs show cost savings. When the rate of return on the new-truck investment equals the company's minimum standard return, it's economically sound to make the replacement investment.

This method is not a miracle. It's only a framework for relevant economic comparisons. Results will be no better than projections of future costs. Size of errors in these future costs will depend both on extent of knowledge of past patterns of cost behavior

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and ability to forecast impact of future changing conditions. (Paper "How to Determine When a Motor Vehicle Should Be Replaced," was presented at SAE Annual Meeting, Detroit, Jan. 12, 1948. The complete paper is available in full from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Dampers Reduce Shaft Torsional Vibration

Digest of paper by

J. C. MILLER

Cummins Engine Co.

FRICTION, tuning, and pendulum dampers reduce the amount of torsional vibration in engine crankshafts, and the silicone viscous damper is a new development counted upon by engine designers for helping to reduce the effect on all amplitudes of vibration over a wide speed range.

Unique properties of silicone, which maintains practically constant viscosity over a wide range of temperatures, have made the simple friction device known as the Lanchester damper, less used than previously.

The damper flywheel mass is completely enclosed by a close-fitting shell which is driven from the crankshaft. This mass is submerged in the silicone fluid. The fluid film is only 0.003 in. thick, and the viscous friction is enough to dampen torsional vibration.

The commonest form of tuning damper is by driving the damper flywheel mass through a layer of rubber. This, more properly called a tuner, tends to shift the critical speed. The design objective is to shift the critical speed out of the engine's operating range.

The harmonic balancer operates on this principle, but uses leaf springs instead of rubber. They both have the advantage of simplicity, but the hysteresis in the rubber and the springs sometimes lose their effectiveness.

The dynamic or pendulum type, generally used in aircraft engines, obtains its dampening effect by a counterweight in the form of a short pendulum.

Its reaction on the crankshaft is equal and opposite to the exciting harmonic for which it was designed. Hence there is no torsional vibration.

By far the most effective, this is the most expensive to manufacture. A separate pendulum mass is required for each order of vibration to be guarded against, and a high degree of precision is required in building it. Like all things mechanical some maintenance is required.

The shaft must be designed as stiff as possible and the rotating masses must be kept as light as practicable if torsional vibration is to be eliminated. (Paper "Natural History of the Crankshaft," was presented at SAE Southern California Section Feb. 26, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Analyzes Spring Types For Car Suspensions

Based on paper by

N. E. HENDRICKSON

U.S. Spring & Bumper Co.

NO one type of vehicle suspension spring is perfect in every respect. Engineers must consider the pros and cons of the several types – leaf, torsion bar, and coil springs – to make the proper selection.

Leaf springs, for example, weigh more than other types. But they also serve as structural members, tying axle to frame without requiring complicated linkage or mechanism.

Excessive and variable leaf-spring friction may impair riding qualities. But if controlled, as in present-day cars with spring covers, friction relieves the damping device. Relieving the shock absorber of much of its work makes possible smaller and cheaper units.

The torsion bar in itself costs less than the leaf spring it replaces. But linkage and anchorage required usually makes the entire unit heavier and more costly. Lacking inherent friction, the torsion bar spring depends entirely on the shock absorber to control oscillations.

Also light in itself, the coil spring can't function without suitable radius arms and linkages. Like the torsion bar, it's friction-free and must depend on the shock absorber for its damping. But this freedom from friction may be very helpful in light cars, where the load carried by spring friction would be fairly large compared with the spring load.

Theoretically air is the ideal suspension medium. It doesn't settle, doesn't fatigue, and costs nothing. But it needs a heavy, expensive mechanism to be made useful in a suspension.

Leaving theoretical considerations to researchers, the engineer selects the spring he wants from the types available and designs into it the ride qualities he wants. Two SAE publications, "Manual on Design and Manufacture of Torsion Bar Springs" and "Manual on Design and Application of Leaf Springs," give much valuable information along this line. (Paper "Spring Suspensions in Automotive Vehicles of Today," was presented at SAE British-Columbia Group, Vancouver, Feb. 9, 1948. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Carter Fuel Pump Balks Vapor Lock

Based on paper by

WILLIAM J. BURNS

Carter Carburetor Co.

CARTER'S electric pusher pump, used as standard equipment on tanks and several current commercial vehicles, goes a long way toward eliminating vapor lock by keeping fuel in the lines under pressure.

In most common system, fuel is moved by suction. Reduction in pressure drops the boiling point and accelerates formation of vapor. A system under pressure operates at relatively high temperatures without fuel in the lines vaporizing.

Carter locates the pump in the coolest spot of the fuel system. It's a full pusher job with no suction lift, mounted inside and at the bottom of the fuel tank.

Inside tank mounting obviates need for shielding the device from objects thrown up from the road.

Since it's a centrifugal-type pump, pressure is controlled by speed and relief devices aren't necessary. The centrifugal type without valves offers an unobstructed passageway into the gas tank for hot expanding fuel in the lines when the pump isn't operating. With the lines vented to the atmosphere through the tank when the engine isn't running fuel can't be trapped between the pump and carburetor, then increase in pressure due to heat, and cause flooding and hard starting.

The unit's effectiveness in supplying solid fuel under adverse conditions was proved by Ordnance tests in the Ethyl Corp. hot room and under actual operating conditions on the California desert. Operating on the desert, the pump supplied fuel to the carburetor with tank temperatures of 150F so that the fuel was boiling violently. (Paper "Description of the Carter Electric Pusher Pump," was presented at SAE Washington Section, Dec. 9, 1947. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Boost 'Copter Payload With Ejector Cooling

Based on paper by

L. L. DOUGLAS

Kellett Aircraft Corp.

RECOUPING nearly 20% payload (equivalent of fan-cooling power consumption) with ejector cooling merited painstaking research to perfect ejector cooling for the XR-10 powerplant. It's done by harnassing, instead of wasting, exhaust-gas energy.

Kellett engineers evolved a practical ejector cooling installation via the try-and-modify route in a three-part test program. The three phases were:

1. Single Ejector Tests - Optimum ejector parameters, suitable for engine cooling needs, were determined from a set-up of a Continental R-975-C1 tank engine and air box.

2. Cooling—System Mock-Up Tests - Air box test-derived information was applied to an actual ejector cooling system on the same engine.

3. Final Installation - The cooling system mock-up on the R-975-C1 engine was redesigned for the R-975-15 on the XR-10 and retested to prove the final design.

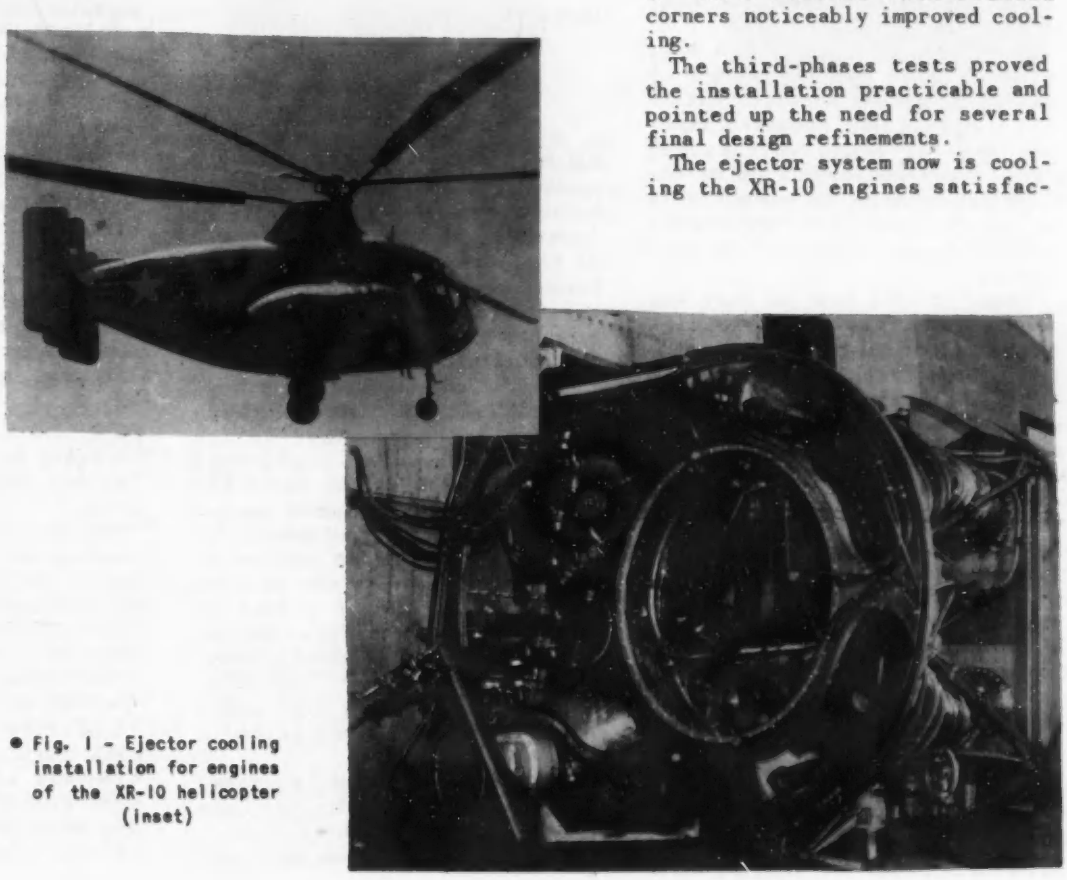
The air box tests brought out several important design facts for this case . . . such as idle nozzle area for no power loss is about 2.15 sq in.; a star-shaped nozzle gives best results; double and triple siamese stacks are best for flow ratios of 6 to 9.

Preliminary tests with the R-975-15 engine, revealed that, for ejector cooling, cylinders for fan cooling won't do. Al-Fin cylinders redesigned with more and deeper fins made a big difference in cooling performance. Same was true for cylinder baffles. For ejector cooling, airflow entrance had to be reduced and baffling extended around the cylinder.

The four ejectors used for this installation were powered by three double siamese stacks and one triple siamese stack. Fig. 1 shows the stack design. A 9-in. cooler also was introduced into the power section. Going to 1 1/2-in star nozzles with rounded corners noticeably improved cooling.

The third-phases tests proved the installation practicable and pointed up the need for several final design refinements.

The ejector system now is cooling the XR-10 engines satisfac-



● Fig. 1 - Ejector cooling installation for engines of the XR-10 helicopter (inset)

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torily without fans. About the only problem remaining - and it's relatively minor - is that the installation somewhat prolongs engine removal time. But even this currently is being corrected. (Paper "Ejector Cooling of the XR-10 Helicopter Powerplant," was presented at SAE Philadelphia Section, Dec. 10, 1947. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Fig. 1 - Track-type landing gear installed on A-20 airplane

Track Landing Gear Held Essential for Large Planes

Based on paper by

BRIG.-GEN. S. D. STURGIS, JR.

U. S. Air Force

TRACK landing gear of the caterpillar type, commonly used on tractors and tanks, seems to be the only feasible solution to the problem of landing and ground handling extremely large aircraft. (See Fig. 1.)

Airplanes equipped with this type of gear can be landed or taxied on ground so soft that if the airplane had standard landing gear it would quickly bog down. But the flexibility of the belt between the bogies actually makes the gear inoperative on hard surfaces, blacktop, and concrete.

Thus, if this type of gear was used extensively for large aircraft, it would be necessary to provide soft runways on all our fields, but this would still be easier than the alternative of making runways at all fields 5-10 times as strong. Costs would be less, too, for at least five fields can be built for very heavy planes using track landing gear for every field constructed to take aircraft using high-pressure tires.

In military strategy there are additional important gains in the saving of time and materials. An airborne engineer battalion can be flown anywhere in the world with comparatively light equipment and build an advanced base in a few weeks. Instead of laboriously piling up concrete in a few vulnerable bases for wheeled aircraft, we can dot the landscape with low-pressure landing fields. This means greater security for our irreplaceable airports and crews, greater tactical flexibility, greater mobility for the Air Force, and quicker, more aggressive action. (Paper "Air Power as Affected by Airdrome Construction and Track-Type Landing Gear" was presented at a meeting of the Central Illinois Section of the SAE, Peoria, Ill., Nov. 24, 1947.)

Gear Testing Experience

Digest of paper by

WARNER T. COWELL

Gleason Works

RIGIDITY of the gear mounting reduces stress on teeth, and because tooth fatigue life varies inversely as the seventh power of the stress, design engineers have a wonderful opportunity to reduce the size and weight of gear drive assemblies.

Initial pitting is where small craters form in the tooth surface; progressive pitting is where pitting has progressed so far that the remaining unaffected areas are too small to carry the imposed load or to transmit motion with the required smoothness.

Pitting is a fatigue failure of the metal just below the surface of the teeth, and is caused by overloading, interferences or wrong tooth shape, misalignment of mountings, improper assembly, or impact loading in high speed gears caused by inaccuracies in the gears themselves.

Abrasion, scratching, scoring, and galling describe various degrees of wear of tooth surfaces.

Contamination of the lubricant is a source for this type of wear.

Failure of the lubricant to prevent metal to metal contact, or to carry away heat generated by tooth engagement causes tooth surface failure.

Extreme pressure lubricants are recommended by gear manufacturers for hypoid and heavily loaded spiral bevel gears. In critical installations surface treatment is helpful.

Misalignment in the assembly or deflections in the mountings brings about serious load concentration and gear failure follows.

For a new design, laboratory life tests provide a measure of the performance to be expected in service.

Maximum fillet radius is used in the root of all heavily-loaded bevel gears, and continued effort is being made by the industry to improve the finish in the root area.

The ground bevel gear has been another step forward. Tooth surface, root radius, and the bottom of the tooth space are blended into one continuous smooth surface in grinding.

The Gleason Works has projected the GMC Fatigue Life Chart beyond 1½ million cycles, and limited data indicates that the projection was satisfactory. We have introduced factors of gear and pinion mountings as they effect stress. (Paper "Bevel Gear Test

Experience, was presented at SAE Philadelphia Section Dec. 10, 1947. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Gasoline A Factor In Engine Sludge

Based on paper by

H. C. MOUGEY

Research Lab. Division, GMC

GASOLINE may cause sludge and varnish even if it meets all recognized gasoline tests, as is proved in one case.

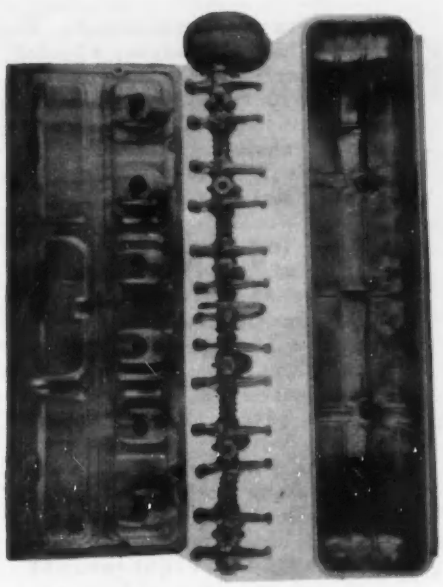
A 1 1/2-ton truck with 13,000 lb of payload was operated for 35,000 miles in California on Heavy-Duty oil (U.S. Army Specification 2-104B, Brand A). Oil was drained every 2000 miles. At the end of 35,000 miles, the engine was disassembled. The parts, shown in Fig. 1, were very clean and engine performance was satisfactory.

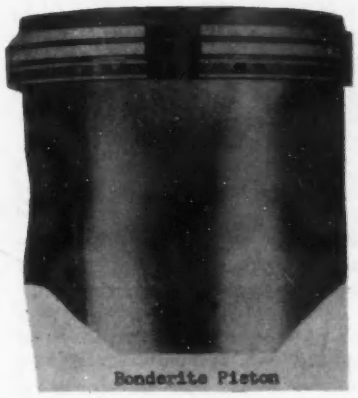
Simultaneously with the California test, a similar test was run in Michigan under the same operating conditions, using the same oil. But instead of getting wonderful results, the engine sludged up badly. At the end of 20,000 miles, the test had to be stopped and the engine overhauled.

Pistons were badly varnished and the engine generally was in bad shape, as in Fig. 2.

Evidentally some new variable caused these very bad results, because according to theories and experience up to that time, the engine should have been clean. Difference in climate couldn't explain it. Only major difference was the gasolines used, although both met tests for good gasoline.

This led to cooperative work on the problem during which The Texas Co. developed a new laboratory test. It showed a great difference in tendency of certain gasoline to generate sludge and varnish even though they met all recognized gasoline tests. (Paper "Sludge and Varnish in Automobile Engines - Their Causes and Cures," was presented at SAE So. New England Section, Hartford, Feb. 4, 1948.)





● Fig. 1 - These engine parts were in good condition after 35,000 miles of operation on Heavy-Duty oil. Vehicle was a 1 1/2-ton tractor-trailer carrying 22,000 lb gross load

● Fig. 2 - The engine from which these parts were taken sludged up badly after only 20,000 miles of operation on Heavy-Duty oil in a 1 1/2-ton truck

Discusses Design Of Gas Turbines

Based on paper by

D. G. SHEPHERD

A. V. Roe Canada, Ltd.

SOME of the development problems encountered in the design of the various components of gas turbine powerplants include:

1. Compressor: The blades present a major problem in the development of an axial-flow compressor. They are complicated to manufacture, since all blade rows should be of different design for optimum performance, and a complete compressor may have as many as 1000 blades. Vibration problems are also numerous, because the blades must be as thin as possible. Compressibility also is troublesome at air speeds approaching that of sound.

2. Combustion chamber: An almost complete lack of fundamental data on which to base design has hindered developments. Thus, combustion-chamber design is almost purely a matter of testing, backed up by certain empirical information that is useful in defining the necessary size, but not for

detailed arrangement. Specific problems include: too high a pressure loss, too large a size needed, too short a life, and inability to burn the cheaper, heavier fuels.

3. Turbine: Problem is one of metallurgy, dur to extremely high operating temperatures. Materials are needed to give longer life at these high temperatures. One of the major problems in design is to construct a multistage rotor without sacrificing some of the advantages of the gas turbine as a powerplant. Considerable work has been done along the lines of blade cooling and the use of ceramic materials.

4. Heat exchanger: The heat exchanger is a fairly straightforward problem, with the exception of the gas ducting and pressure loss, since design data are available and materials are no particular problem. (Paper "Some Problems in Development of Gas Turbines" was presented at a meeting of the Canadian Section of the SAE, Toronto, Canada, Oct. 15, 1947. This Paper is available in full from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Lists Requirements For Good Propellant

Digest of paper by

T. F. REINHARDT

Bell Aircraft Corp.

THERE are so many requirements which rocket propellants ought to meet that no combination yet tried meets all requirements, but several - like hydrazine, alcohol, and aniline - look promising.

The basic requirement is high specific impulse, which is the ratio of thrust (lb) to rate of propellant flow (lb per sec). To minimize the denominator, propellants should consist of elements of low atomic weight and molecules of low molecular weight. It can be shown that specific impulse increases with decreasing molar specific heat and with increasing heat content of the combustion gases, as well as with pressure ratio. For low molar specific heat, the combustion gases should be monatomic or diatomic gases in preference to more complex molecules.

Table 1 compares specific impulses of some light-weight, simple-molecule propellant combinations.

Unfortunately, the best of these high-specific-impulse propellants do not satisfy all the other requirements - ease of handling, ease of storing, high density, low combustion, temperature, ease of ignition, availability, low cost, low heat of formation, high content of active elements, and safety in operation.

Both hydrogen and fluorine are difficult to handle and would require heavy equipment. Oxygen must be stored under pressure as a liquefied gas at normal temperatures. Lithium compounds have high heat of formation.

Some of the propellants which do not show up so well on the specific-impulse basis have compensations. Hydrazine combines quite good performance with high density, negative heat of formation, and the ability to ignite spontaneously with nitric acid. But, so far, hydrazine is scarce and costly.

Ethyl alcohol - containing 13% hydrogen, 35% oxygen, and 52% carbon - has performance equal to that of gasoline, plus the advantage of higher density. It ignites spontaneously with nitric acid, eliminating the need for an ignition system.

Furfuryl alcohol and aniline have been used together as fuel, with nitric acid as the oxidizer. Although the specific impulse of the combination is only moderate, it has high density and ignites spontaneously.

The drawback to spontaneous ignition is the fire hazard. Alcohol can be used with liquid oxygen, a combination which will not ignite spontaneously. And neither of these propellants is dangerous in itself, as fuming nitric acid is.

It might be possible to make good rocket fuels out of certain hydrocarbons by substituting amino groups for some of the hydrogens. The amines not only have higher performance, but also higher density and higher boiling points than the corresponding hydrocarbons.

(Paper "Factors Affecting Selection of Propellants for Rocket Powered Aircraft," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 13, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 1 - Comparison of Heat Content, Specific Heat, and Specific Impulse of Rocket Gases

Reaction	h_c (Btu per lb)	C_p	$h_c \cdot \eta_t$	I_{sp} (lb-sec per lb)
$H_2 + F_2 = 2HF$	5760	8.65	2880	373
$2Li + F_2 = 2LiF$	5670	8.60	2840	370
$2H_2 + O_2 = 2H_2O$	5780	13.10	2125	320
$2B + 3F_2 = 2BF_3$	6820	22.20	1610	279
$C + O_2 = 2CO_2$	3860	14.60	1296	251
$2C + O_2 = 2CO$	1690	8.90	829	200

High Compression Engine Freed of Most Troubles

Based on paper

By DARL F. CARIS
and ARCHIE D. McDUFFIE

General Motors Corp.

RESEARCH has overcome most of the obstacles to a high compression engine. Full realization of the 35 to 40% economy gains promised by the experimental 12.5 compression ratio engine await conventional evolutionary progress.

This work showed such engines can be built to weigh less per horsepower than present-day engines. And if the structural design is right, the engine will operate smoothly.

From the car builder's standpoint, best way to bring on the high compression engine is to increase compression ratios in each succeeding model. This also will give the petroleum industry a chance to develop refining equipment for production of the 99/87 octane number fuel the high compression ratio engine needs. (Paper "High Compression Ratios in Automotive Engines," was presented at SAE Cleveland Section, Dec. 8, 1947.

Modern Trends In Lubricants

Digest of paper

By BRUCE B. FARRINGTON

California Research Corp.

SIMPLIFICATION of lubrication is keeping pace with the modern automobiles, trucks, and buses.

Introduction of hydraulic clutches and automatic transmissions has brought about development of transmission fluids of increased resistance to oxidization. The same fluid is used in both the hydraulic unit and the transmission in the Hydra-Matic and the White Hydro-Torque drive. Multi-purpose lubricants had to be developed.

General characteristics of passenger car clutches and automatic transmissions are shown in Table 1. The manufacturers supply the clutch fluid.

Data for bus and tractor hydraulic torque converter systems are given in Table 2, and comparison of the properties of automotive hydraulic power transmission fluids now used in the United States is shown in Table 3.

The Spicer unit uses a much lower viscosity than others because the torque converter fluid is not required to lubricate gears in addition to the hydraulic unit. The new Buick Dynaflow foreshadows increasing use of fully hydraulic transmissions in cars and buses.

An important step in the simplification of differential lubricants was achieved by the Army Ordnance specification 2-105B, developed in the closing years of the war.

These lubricants contain a

CONTINUED ON PAGE 86

TABLE 1
PASSENGER CARS
HYDRAULIC CLUTCHES AND AUTOMATIC TRANSMISSIONS

Clutch	*Dodge* *Manual Friction (Dry); Hydraulic*	*Chrysler De Soto* *Manual Friction(Dry); Hydraulic*	*Cadillac Oldsmobile* *Automatic Friction (Wet); Hydraulic*
Total Speeds Forward	3	4	4
Automatic Gear Shifts Forward	0	2	4
Hydraulic Clutch Fluid	*Special	*Special	*Special
Gear Lubricant	SAE 90	SAE 10W	Same as Clutch Fluid

*Supplied by Manufacturer

TABLE 2
BUS AND TRACTOR
HYDRAULIC TORQUE CONVERTER SYSTEMS

	White	*Spicer (G.M.C., Twin-Coach, Mack, Allis-Chalmers)*
Control	Electro-pneumatic	Electro-pneumatic
Clutch	Converter free wheels as hydraulic clutch at high speed range of each gear	Friction, double acting, dry
Transmission	Single-stage torque converter, 2 forward gears and reverse gear. Automatic forward gear shift	Three-stage torque converter and reverse gear. Direct drive at high speed
Lubricant and Power Transmission Fluid	Approved SAE 10 and SAE 20 inhibited oils	60 SSU at 100 F inhibited (lates models) Diesel fuel (tractor, older models) Mineral seal (inhibited oil replacing this)
Fluid Circulating System	Double rotor pump-one side 40 PSI to converter, other side scavenge sump to oil cooler and reservoir	Injector or gear pump to converter, cooler, filter, and reservoir. Oil at 100 PSI
Gear Lubricant	Approved SAE 10 and SAE 20 inhibited oils	SAE 50 for reverse gear and angle drive

TABLE 3
COMPARISON OF PROPERTIES OF
AUTOMOTIVE HYDRAULIC POWER TRANSMISSION FLUIDS

Type	*Chrysler De Soto Dodge Fluid Drive*	*Cadillac Oldsmobile Hydra-Matic*	*White* *Hydro-Torque Drive* *A (Summer)*	*B (Winter)*	*Spicer* *Torque Converter* *Commercial Inhibited Oil*	*Mineral Seal Oil*	*Diesel Fuel*
Flash, F	420	330	380	360	290	290	120
Viscosity, SSU 100 F	170-190	200	240-400	160-240	60	55	30-40
Viscosity Index	90	130	85	85	70	-	-
Pour Point, F	-15	-30	0	-10	Below -70	-60	10° Below Atmos.
Oxidation Inhibitor	Yes	Yes	Yes	Yes	Yes	No	No
Oiliness	No	Yes	No	No	Yes	No	No
Extreme Pressure	No	Yes	No	No	No	No	No
Foam Inhibitor	Yes	Yes	Yes	Yes	Yes	No	No

About S

VANCE IN DUAL ROLE

HAROLD S. VANCE, right, who will serve as both president and chairman of Studebaker Corp. during the absence and until the return of PAUL G. HOFFMAN, who resigned his $96,000-A-Year job as president in order to head the European Recovery Program.

JOHN A. BRITTON, JR., has been elected president of Enjay Co., Inc., New York City, chemical products marketing affiliate of Esso Standard Oil Co. He became a vice-president of this company upon its organization in 1947. Prior to that he was with Esso Standard Oil Co. (formerly Standard Oil Co. of New Jersey) and affiliated companies for 27 years.

HARRY BERNARD has been appointed chief engineer of Mack Trucks, Inc., New York City to replace W. M. WALWORTH, who recently resigned. Bernard had been director of Service & Service Engineering for the past three years. He assumes overall responsibility for the engineering of the company's entire line of trucks, buses and fire apparatus.

R. W. ROUSH has been appointed to the post of chief materials engineer for Timken-Detroit Axle Co., Detroit. Roush, chief metallurgist for the Company since 1935, is responsible for the quality of materials, metallurgical and chemical processes, and the direction of laboratories. He is vice-chairman of the SAE Iron & Steel Technical Committee.

ROBERT TWELLS, manager of Spark Plug Operations for the Electric Auto-Lite Co., Fostoria, Ohio, has been elevated to the post of vice-president. Twells joined Auto-Lite in 1935 to organize spark plug operations after having served with other spark plug companies and General Electric Co.

JAMES D. MOONEY, president of Willys-Overland Motors, was re-elected a board member of the National Industrial Conference Board for the coming year.

SIDNEY G. HARRIS has been employed as sales manager of the Automotive Division of E. F. Drew & Co., Inc. In the past he has been connected with Continental Motors Corp., Detroit; Macmillan Petroleum Corp., Los Angeles; and Petroleum Solvents Corp., New York City.

ROBERT E. BUSEY, acting chief engineer for Willys-Overland Motors, has been promoted to chief engineer. A former executive engineer for the White Motor Co., Busey joined Willys-Overland a year ago as special assistant to the chief engineer. In his new post, he succeeds WALTER D. APPEL, who has been appointed director of procurement for the company.

Following ten years in the Army Reserve Service wnd five years on active duty during the war, M. A. KINLEY has resigned from Ethyl Corp. and accepted a commission as lieutenant colonel in the regular army. He will be stationed in the Ordnance Department, Chicago., as assistant to the chief of the Chicago Ordnance District.

JAMES Y. SCOTT, president of Van Norman Co., Springfield, Mass., and president of the Morse Twist Drill Co., New Bedford, Mass., was named special emissary by the American Society of Tool Engineers to the Institution of Production Engineers in England. He attended a meeting of the

SAE Members

British organization at Wolverhampton, England, on May 28 and presented the president of the Institution an honorary life membership in the ASTE.

President BEN F. HOPKINS became chairman of Cleveland Graphite Bronze Co., and JAMES L. MYERS moved from executive vice-president in charge of sales to senior vice-president, while J. J. MCINTYRE, senior vice-president, became vice-chairman of the board.

The other officers promoted by directors were LeROY W. CHRISTENSON, from sales manager to vice-president and sales manager; JOHN W. DIXON, from treasurer and controller to vice-president and treasurer and WILLIAM G. LAFFER, from works manager to vice-president and works manager.

Recently made chief engineer of Adel Precision Products Corp., Earthmaster Division, Hollydale, Calif., ROBERT E. HARTSOCK had been a consultant with Aerco in Hollydale.

WILLIAM P. KALB recently became sales engineer with Skinner Purifiers Division of Bendix Aviation Corp. in Detroit. Prior to this post, he was research engineer for the Ford Motor Co. in Dearborn, Mich.

Recently graduated from Parks College of Aeronautical Technology, East St. Louis, Ill., HENRY WILLIAM ELLSWORTH, Jr. is air freight agent for United Airlines, Inc., New York City, KNIGHT H. MORTON is aircraft mechanic for Northwest Airlines, Inc., St. Paul, Minn., and KEITH LEONARD DEAVER is a mechanic for Northwest Airlines, Inc. at Minneapolis, Minn.

J. M. Van LAW, until recently assistant operations manager of the Atlantic Division, Pan American World Airways, has resigned this post to join the Massachusetts Mutual Life Insurance Co., New York City. He has been active in Metropolitan Section and served two terms as a member of its Governing Board.

No longer a laboratory research analyst with Lockheed Aircraft Corp. in Burbank, Calif. JOHN F. WHITMORE has become an orange rancher with the Richard Co. in Visalia, Calif. He will act as technical adviser on frost protection.

WILLIAM T. De CAPUA, formerly chief engineer for the Twin Coach Co. has been named consulting engineer of Beaver Metropolitan Coaches, Inc., Beaver Falls, Pa. He had worked in the Engineering Department of Twin Coach since 1927.

FRED E. WEICK, famous as the designer and developer of the "Ercoupe" - the first two-control airplane - has been appointed distinguished professor and research engineer at Texas A&M College. He will direct the Personal Aircraft Research Center being established in the Department of Aeronautical Engineering at the College.

S. M. BATORI is now associated with De Witt C. Griffin & Associates, Seattle. This firm of consulting engineers is broadening the scope of its activities to include a comprehensive consulting engineering service in every branch and every phase of engineering. He had been with Connecticut Railway & Lighting and with the Sun Oil Co. before becoming an independent consulting engineer.

FREDERICK C. YOUNG has been appointed assistant director of chemical engineering at the Ford Motor Co., Dearborn, Mich. He was formerly head of Metallurgical Division of the Chemical Engineering Department. Young is chairman of the SAE Iron & Steel Technical Committee.

SAE Fathers and Sons . . . . .

CORNELL JANEWAY, left, who is beginning his engineering career with Ethyl Corp., and his father, ROBERT N., head of the dynamics research department of Chrysler Corp. A former chairman of the Detroit Section, the elder Janeway has been a frequent author of SAE technical papers.

R. D. EVANS, far left, is manager of tire design research of the Goodyear Tire & Rubber Co., Akron, Ohio. He has been a member of the SAE since 1938, and he has presented a number of papers on pneumatic tires at meetings of the Society. His son, D. WILLIAM is a design engineer with the Towmotor Corp., Cleveland, Ohio.

At the far right is T. B. MOORE, president and general manager of the Detroit Ball Bearing Co., Detroit, with three of his sons who are SAE members. They are affiliated with the Detroit Ball Bearing Co. Left, seated, is T.P., treasurer. Standing, left to right, are R. JOHN, secretary and EDWARD JOSEPH, branch manager.

S. E. ELLERBE, who had been fleet engineer with Ethyl Corp., Atlanta, Ga., is secretary and service manager of the South Alabama Auto Co., Inc., Dothan, Ala.

Previously an automotive engineer with the American Oil Co. in Baltimore, Md., JAMES A. SCOBIE, Jr. has become manager of the Automotive Research Laboratory of the Pan American Refining Corp., same city.

ROBERT L. CLINTON is now a draftsman with Consolidated Vultee Aircraft Corp., Fort Worth Division in Fort Worth, Tex.

No longer flight test powerplant engineer with Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y., HERMAN H. BEMENT is assistant manager with Edgewood Farm in Hebron, Ind.

Having left the Fruehauf Trailer Co. of Detroit, where he was general works engineer, FRED E. FRICKE has connected with the Kraft Foods Co. of Chicago as chief engineer.

JOHN M. FLOYD, vice-president and a member of the board of directors of the A. O. Smith Corp., has been elected a director of the Bendix Aviation Corp.

Recently graduated from Northeastern University in Boston, Mass., ERIC A. MEYER has become a junior test engineer for the York Corp. in York, Pa.

NORMAN J. LAW recently became associated with the American Bosch Corp. in Springfield Mass. as a service sales representative.

C. F. DRUMM, SR. is now general engineer of the Engineering Department for Mack Mfg. Corp. in Allentown, Pa. He was formerly contact engineer between the Service Engineering Department at Long Island and the Engineering Department of this company.

TALKING THINGS OVER ON THE BOW OF THE M-V-PAMATOMIGE WITH SKIPPER TOM J. COLLINS, LEFT IS SOUTHERN CALIFORNIA CHAIRMAN L. D. BONHAM

No longer a lubrication and automotive engineer with the Texas Co. in Seattle, Wash., EARL EUGENE PHILLIPS has become chief lubrication engineer for Inland Empire Refineries, Inc., Northern Division of Wasatch Oil Co., Spokane, Wash.

Now in the employ of United Aircraft Service Corp., East Hartford, Conn., as a field representative for Pratt & Whitney Aircraft Engines, JAMES B. SPRINGFIELD had been general manager of Indiana Air Service, Inc., South Bend, Ind.

ELI SHAPIRO, chief engineer of the Dearborn Stove Co., Dallas, Tex., has been elected one of the six representatives of the nation's gas heater manufacturers on the American Gas Association Sub-Committee on Approval Requirements for Space Heaters.

HARRY L. SHOWALTER, JR., has formed his own company to be known as Girard Associates. They are specializing in sales and engineering related to the forge and press shop field. Its principal offices are located in Philadelphia and Chambersburg, Pa.

L. L. COLBERT, president of the Dodge Division of the Chrysler Corp., Detroit, took part in the opening of the new Dodge San Leandro, Calif., plant on May 4. This is the first all-Dodge assembly plant to be opened in California.

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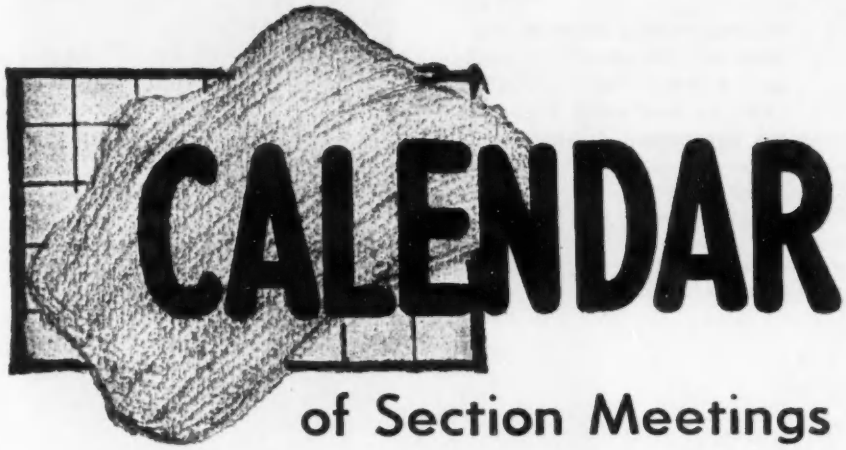

BRITISH COLUMBIA GROUP - June 10
York Room, Hotel Georgia, Vancouver, B.C.; dinner 7:00 p.m. Meeting for members and applicants only to get better acquainted with fellow members, receive chairman's and treasurer's annual reports, scrutinize and count ballots and install elected officers for 1948-49.

CLEVELAND - June 18
Sleepy Hollow Country Club; annual outing and dinner.

KANSAS CITY - June 9
Southwestern Bell Telephone Co. Building. 11th and Oak Sts., Kansas City, Mo.; trip through telephone facilities 5:30 p.m. Dinner to follow tour.

DETROIT - June 25
Grosse Pointe Yacht Club; dinner-dance. Ladies Night.

MILWAUKEE - June 11
Ozaukee Country Club, few miles north of Milwaukee; dinner 6:30 p.m. Annual Ladies Night Entertainment and Dinner Dance.

NORTHERN CALIFORNIA - June 23
Treasure Island Officers Club, San Francisco; dinner 6:30 p.m. Light Aircraft Vapor Lock Problems - Dr. A. G. Cattaneo, Shell Development Co., Emeryville, Calif.

ST. LOUIS - June 8
Garavelli's; dinner 7:00 p.m. Engine Design for Use With Fuels, Past, Present and Future. M.M. Roensch, Ethyl Corp. Social Hour - courtesy Shell Oil Co.

VIRGINIA - June 14
Hermitage Country Club, Richmond, Va.; dinner 7:00 p.m. Standard Brands Maintenance - Harry Matthews. Social half hour 6:30 p.m.

WILLIAMSPORT GROUP - June 4
Lock Haven Country Club, Lock Haven, Pa.; dinner 7:30 p.m. Annual Ladies Night. Films - Antarctic Expedition and Operation Cross Roads. Brief on pertinent details concerning films - B. M. Robinson, U.S.N.

SAE NATIONAL MEETINGS

MEETING	DATE	HOTEL
SUMMER	June 6-11	French Lick Springs, French Lick, Ind.
WEST COAST	Aug. 18-20	St.Francis, San Francisco
TRACTOR and DIESEL ENGINE	Sept. 7-9	Schroeder, Milwaukee
AERONAUTIC and AIRCRAFT Engineering Display	Oct. 6-9	Biltmore, Los Angeles
PRODUCTION MEETING and CLINIC	Oct. 21-22	Statler, Cleveland
FUELS and LUBRICANTS	Nov. 4-5	Mayo, Tulsa
	• 1949	
ANNUAL MEETING and Engineering Display	Jan. 10-14	Book-Cadillac, Detroit
PASSENGER CAR	March 9-11	Book-Cadillac, Detroit
TRANSPORTATION	March 28-30	Statler, Cleveland

Student Branch News

Four student branches mixed a little psychology with their engineering. Arrangement of instrument of instrument panels, location and kind of indicators and dials, even knob diameters, are all important to the efficiency of man-machine combinations, H. A. Voss of the Navy's Human Engineering Section told CCNY Student Branch.

The Navy is studying the effects on humans of temperature, acceleration, and the composition of air, as well as motor performance of humans, Voss said.

It's good sales psychology to "let the customer know what your company is doing for him and how it is planning for his future needs," George J. Haislmaier advised Wisconsin University's Student Branch on April 14.

He pointed out that new ideas are strong selling points when presented by an engineer who understands them. At the March 10 meeting, C. Furgason of the Ladish Drop Forge Co. described how forgings are designed and manufactured.

Enrolled students from Fenn College and Case Institute discussed problems of young engineers with a panel of six practicing engineers at the Cleveland Section's annual student dinner, April 21.

On the panel were Muron S. Curtiss, Warner & Swasey Co.; Carlton Kemper, NACA; George T. Trundle, Trundle Engineering Co., Albert C. May, Peerless Automatic Machine Co.; N.M. Forsythe, Pesco Products Co., and Robert Cass, White Motor Co.

Discussion highlighted the growing tendency of employers to interview not only the man but also his wife to determine how the whole family will feel about moving, traveling, and entertaining.

On April 30, Fenn students heard S. D. Sanders of the White Motor Co. talk on industrial engineering.

Purdue Student Branch entertained the Indiana Section on April 15 at a meeting on hydraulic couplings and torque converters. W. F. Shurts, Twin Disc Clutch Co. explained the difference between fluid couplings and torque converters - a coupling functions like a friction clutch, but a converter has a reaction member which enables it to multiply torque.

During a lab tour, the guests were impressed by Purdue's new 200-hp diesel engine connected to an electric dynamometer through an hydraulic torque converter.

On March 23, the Purdue Branch heard that existing transmission devices fall short of performance objectives because of compromises due to cost, need for reliability, patent restrictions, avoidance of competitors' principles, and adherence to features initially tried.

This was explained in a paper by W. B. Barnes, Barnes Motor Developments Co.; C. H. Baker, Jr., Warner Gear Division, and W. A. Barnes, Purdue student.

Transmissions were the topic also at Illinois Institute of Technology when the SAE Student Branch met ASME student members to hear L. H. Nagler give his paper on March 30. He reported that more engineering time and money has been spent on automatic transmissions than on any other part of the automobile.

At a meeting March 9, Norman C. Penfold, chairman of student activities for the Chicago Section, explained the benefits of student membership - that professional societies expand technical knowledge as well as social contacts.

RPI Student Branch produced its own speakers for the April 15 meeting, which featured a contest on souping up stock cars.

Kurt Sense won $5 for his talk on combining a Buick engine and a Plymouth frame. Second prize of $2 went to Bill Moody, who explained how he built a racing car around a Ford Model B engine. Ted Rising told of his experiences with lowered-back-pressure engines.

Talking to the M.I.T. Student Branch on April 14, Prof. J. P. DenHartog told how counterweights are developed to minimize vibration in engines of two or more cylinders by stabilizing the center of gravity and how dampers are added at the front end of the crankshaft to absorb the energy of secondary torsional vibrations.

Triptane may make it possible to boost compression ratios to new heights, but now it costs about $25 per gal, Frank Elliott of the Ethyl Corp. reported to the Student Branch at Oregon State College on March 11.

With pure triptane, compression

Students who described their model and full-size racers at Detroit Section's student dinner on April 5 were, left to right, James LaPointe, Detroit Institute of Technology; Richard C. Edwards, Chrysler Institute of Engineering; Charles Backman, Michigan State College; Carl Braun, Ford Engineering School; Gordon Millar, University of Detroit; Walter Mills, Lawrence Institute of Technology; and Robert N. Smith, General Motors Institute of Technology

ratios can go up to 300 psi, Elliott said.

At the Fred Jones Mfg. Co. in Oklahoma City, the University of Oklahoma Student Branch watched Ford engines being dismantled, cleaned, and reconditioned on an assembly line.

Jones engineers have built their own equipment for reboring four or six cylinders in one operation, they learned, but all Processes are controlled by Ford specifications and Ford representatives visit the plant regularly.

Northrop Aeronautical Institute's Student Branch had a chance to examine a cutaway model of a refrigeration unit which can deliver 7 lb of air per min at a turbine speed of 100,000 rpm, yet fits in the palm of the hand, when Mr. Drexel of Airesearch Manufacturing Co. discussed the cooling of cockpits in high-speed aircraft on Feb. 25.

General Motors Institute Student Branch, Section B, held its annual dinner meeting on Feb. 26, as Section A had done on Jan. 29. Guests were James Allen, project engineer, and Ward Byrne, personnel director, of the Chevrolet-Flint Assembly Plant.

Byrne explained the advantages of the overhead conveyor system used at Flint and said that more plants are being planned on that idea. Eric Halvarson and Walter Unterbert had charge of the meetings.

SAE Members Asked To World Mechanics Event

A cordial invitation is extended to all SAE members to participate in the Seventh International Congress for Applied Mechanics to be held in London, England, Sept. 5-11, 1948.

The technical sessions will be organized under the following sections: (1) elasticity and plasticity; (2) aerodynamics, hydrodynamics, meteorology; (3) thermodynamics, heat transfer, and so forth; and (4) vibrations, lubrication, and experimental methods. In addition, as many as 10 general lectures or surveys are contemplated on subjects likely to be of interest to members.

During the week following the Congress, inspection trips are being planned to the National Physical Laboratory, the Royal Aircraft Establishment, the National Gas Turbine Establishment, and the General Electric Research Laboratories.

A committee on United States participation has been organized under the chairmanship of Dr. Hugh L. Dryden, with C. E. Davies as vice-chairman. Its membership includes representatives from the following organizations which organized participation in the 1946 Congress for Applied Mechanics held in Paris:

American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Institute of Mining Engineers
American Institute of Physics
American Mathematical Society
American Society of Civil Engineers
American Society of Mechanical Engineers
Institute of the Aeronautical Sciences
Society of Automotive Engineers

T. B. Rendel has accepted SAE President Pigott's appointment to serve as SAE representative on this committee. SAE members interested in participating in the Congress, either by contributing papers or attending, or both, are requested to communicate directly with Rendel. He can be reached in care of Shell Oil Co., Inc., Aviation Department, 50 West 50th St., New York City.

You'll Be Interested To Know That

John H. Hunt represented SAE on the American Standards Association Member Conference on incorporation of ASA. The conference was held on May 5.

SAE members in Atlanta, Ga., have been holding a series of informal meetings in recent months. Speakers addressing the group have included J. W. Lane of Socony-Vacuum Oil Co., and Walter E. Thill of the Federal-Mogul Corp. SAE members active in organizing the meetings include the following men selected as temporary officers: Randolph Whitfield, chairman; John C. Rogers, co-chairman; H. M. Conway, Jr., secretary and membership chairman; and W. P. Turner, treasurer. Original chairman was S. E. Ellerbe, who resigned this office when he moved out of the area.

Appointed to represent SAE on an inter-society committee to further the aims of the Thomas Alva Edison Foundation, Inc. are five SAE past-presidents: H.W. Alden, James M. Crawford, John H. Hunt, Ralph R. Teetor, and H. T. Woolson. Request for SAE cooperation came from SAE Past-President Charles F. Kettering on behalf of the Foundation.

J. M. Shoemaker has been named SAE representative on the Daniel Guggenheim Medal Board of Award to serve three years beginning Oct. 1, 1948. Other SAE members of the Board are W. J. Blanchard and R. W. Young.

Representing SAE on a committee to organize United States' participation in the Seventh International Congress for Applied Mechanics is T. B. Rendel. The Congress is scheduled for London, Sept. 5-11, 1948.

TECHNICAL COMMITTEE PROGRESS

"Sow's Ear" Boron Yields "Silk Purse" Alloy Steels

INEXPENSIVE boron needling imparts high-alloy properties to low-alloy steels, says a new SAE report covering tests of commercial parts produced from nine different needled steels. (See Table 1.) Based on findings from this project, steel-mill metallurgists see possibilities of boron additives easing the tight steel alloy-element situation.

Three highlights emerge from this investigation of steels from commercial-size heats. They are:

1. Boron treatment increases considerably the hardenability of both carbon and alloy steels. It also improves mechanical properties of carbon steels in the quenched and tempered conditions, with minor exceptions.

2. In all parts satisfying carbon content and hardenability needs, special boron-treated steels were suitable alternates for many conventional steels of higher alloy content.

3. Fabricating qualities – cold forming, forging, heat-treating, and machining – of boron-treated steels generally equalled those of comparable conventional alloy steels.

Needling appreciably increased Jominy hardenability of all steels tested, says the report. Fig. 1 compares hardenabilities of 1066 steel in treated and un-

SAE TECHNICAL BOARD

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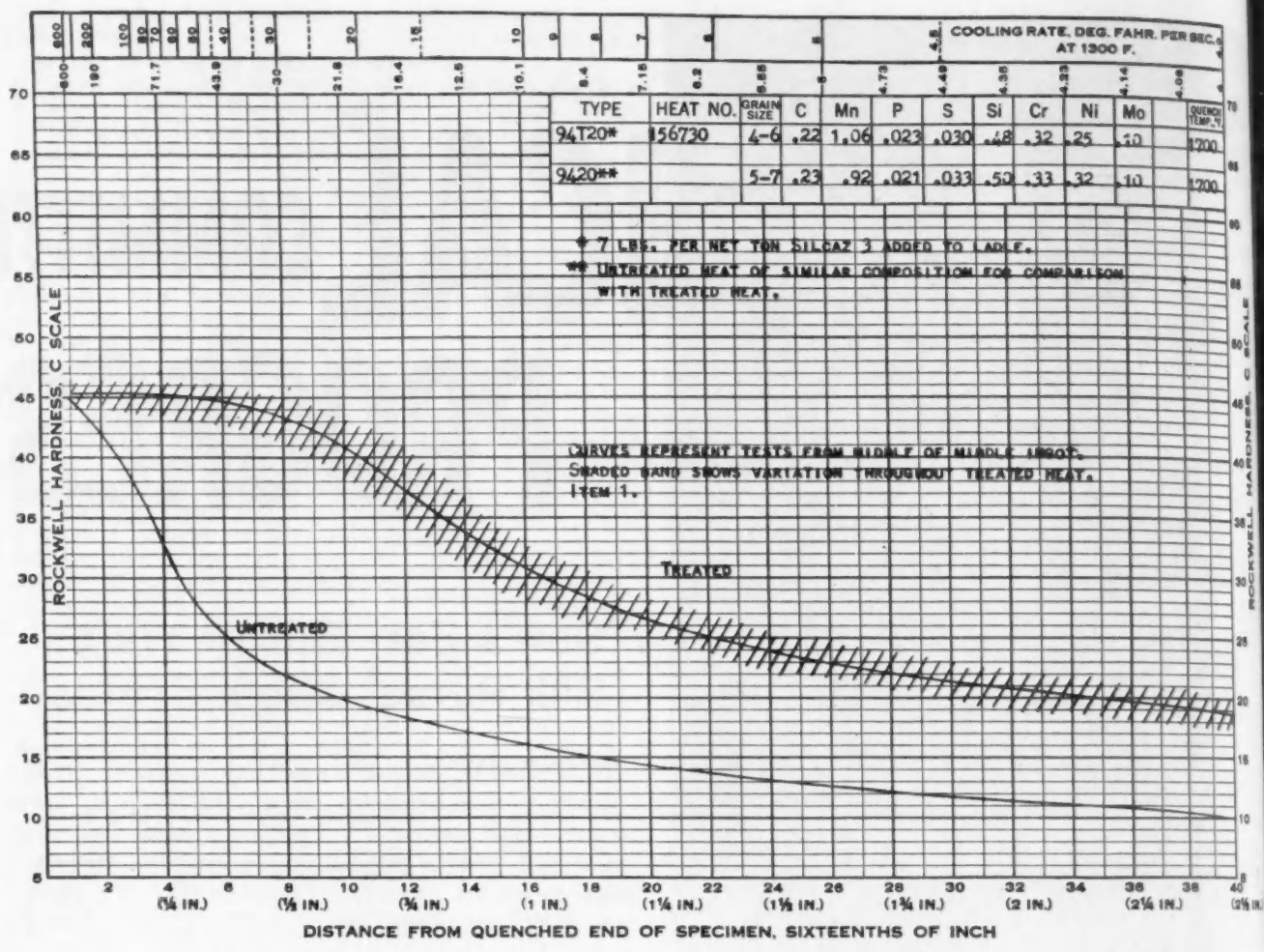

COOLING RATE, DEG. FAHR. PER SEC. AT 1300 F.
TYPE | HEAT NO. | GRAIN SIZE | C | Mn | P | S | Si | Cr | Ni | Mo | QUENCH TEMP. °F
94T20* | 156730 | 4-6 | .22 | 1.06 | .023 | .030 | .48 | .32 | .25 | .10 | 1200
9420** | | 5-7 | .23 | .92 | .021 | .033 | .50 | .33 | .32 | .10 | 1200
* 7 LBS. PER NET TON SILCAZ 3 ADDED TO LADLE.
** UNTREATED HEAT OF SIMILAR COMPOSITION FOR COMPARISON WITH TREATED HEAT.
CURVES REPRESENT TESTS FROM MIDDLE OF MIDDLE HEAT. SHADED BAND SHOWS VARIATION THROUGHOUT TREATED HEAT. ITEM 1.
TREATED
UNTREATED
ROCKWELL HARDNESS, C SCALE
DISTANCE FROM QUENCHED END OF SPECIMEN, SIXTEENTHS OF INCH
(¼ IN.)
(½ IN.)
(¾ IN.)
(1 IN.)
(1¼ IN.)
(1½ IN.)
(1¾ IN.)
(2 IN.)
(2¼ IN.)
(2½ IN.)

● Fig. 1 - Needling steels with boron additives boosts hardenability of both carbon and alloy steels, tests show. This is what it does to hardenability of SAE 1066

treated conditions. Hardenability varied over a considerable spread for some of the steels; but this partially may be due to different austenizing temperatures used by various participants in the program.

Results indicated a trend toward a lower multiplying factor for boron treatment with increased carbon content, and a higher one with increased alloy content. See Table 2.

Quenched and tempered tensile properties of the needled steels were good, the investigators found. P-values were more or less in the expected range for these steel types in the hardness levels tested. (P-value = $\frac{T + 6R}{5}$, where T = ultimate strength in 1000 psi and R = % reduction of area.) Endurance properties also fell within expected range of alloy constructional steel. The report details laboratory testing results for these properties.

To evaluate performance of boron steels in commercial parts, the Caterpillar Tractor Co. fabricated the bulk of material from each heat into production parts. Table 3 lists the parts made from each steel together with materials regularly specified for them.

Production quantities of these parts were manufactured, and placed in service in the first half of 1944. On Sept. 20, 1946, Caterpillar advised that field performance of these parts was "satisfactory on all counts."

Table 1 - Heats Made for Project

Steel Number	*Boron Addition Agent*
Accepted Heats	
10T22	Ferroboron - Mold
10T34	Grainal 79 - Ladle
10T41	Grainal 79 - Ladle
10T51	Grainal 79 - Ladle
10T66	Ferroboron - Mold
94T20	Silicaz 3 - Ladle
94T30	Grainal 79 - Ladle
94T40	Silicaz 3 - Ladle
94T50	Grainal 79 - Ladle
Rejected Heats	
10T41	Ferroboron - Mold
10T51	Ferroboron - Mold
94T20	Ferroboron - Mold
94T40	Ferroboron - Mold

Table 2 - Approximate Critical Sizes and Multiplying Factors for Several Boron Steels

Steel Type	D_1 - Inches Untreated*	D_1 - Inches Treated**	Multiplying Factor
1022	1.2	2.3	1.97
1041	1.2	2.0	1.7
1051	1.4	2.1	1.5
1066	1.8	2.4	1.3
9420	1.9	4.3	2.3
9440	4.2	7.5	1.8

* "Ideal Critical Diameter" derived from Jominy hardenability.

**D_1 treated divided by D_1 untreated.

Table 3 - Parts Made by Caterpillar Tractor Co. from Boron-Treated Steels

Special Steel	*Specified Steels*	*Part Applications*
10T22	SAE 4615, NE 8620	Flywheel clutch sliding collars; drive couplings; fuel valve adapters
10T34	SAE 4140, NE 8637	Connecting rod bolts, 11/16-in. diameter
10T41	SAE 4145, NE 8645	Spring clips, up to 3/4-in. diameter
10T51	SAE 4150, NE 8645	Spring clips, 7/8 to 1-in. diameter; shafts
10T66	SAE 9255, NE 8655	5/16 to 7/16-in. thick leaf springs
94T20	SAE 4620, NE 8825 SAE 4820 (Limited)	Gears
94T30	SAE 4135, NE 8630	Scarifier tooth tips
94T40	SAE 2345 (Low Side chemistry), NE 8645	Axle Shafts
94T50	SAE 2345 (High side chemistry), Special 86T45*	Clutch shafts; axle shafts

*Boron-treated steel of NE 8645 chemistry.

As of that date, the company hadn't received any complaints or return of service failures involving boron steel parts.

The new report also points out that Caterpillar and other manufacturers experienced no fabricating difficulties with boron steels.

For example, Caterpillar reported excellent forming properties for 10T34 steel based on cold upsetting of 30,000 connecting rod bolts. Six shops that made gear forgings from 94T20 steel found no difference in forging properties between this material and NE 8725. Same was true with torque-rod end pins of 94T40.

Production quantities of parts were heat-treated in production equipment. No unusual difficulties developed either in carburizing and hardening 10T22 and 94T20 or in quenching and tempering other steels in these applications.

Where hardenability was insufficient to harden the section properly, some adjustment in procedure had to be made. A case in point is spring clips made from both 10T41 and 10T51. They were quenched in a special accelerated quenching oil because the as-quenched hardness was not high enough in regular oil. The clips cracked in both cases when water-quenched.

The special steels annealed to a lower hardness, generally, than materials for which they were substituted. In some cases they yielded somewhat inferior surface finishes. But one tractor manufacturer could find no difference in machinability between the specification steel - NE 8620 - and 94T20, from 1000 lb of which he fabricated tractor gears.

Work for Army Ordnance on boron needling of one steel, summarized in an earlier SAE report, delayed this program. The Ordnance project concerned itself with an experimental 100-ton heat. Seven different kinds of boron additives, with which this steel (0.45 carbon - 1/50 manganese) was needled, were evaluated. Also described in this first report are the properties of this one-boron-treated steel in army truck parts and M-1 rifle parts. (See Journal, April, 1947, article "Low Cost Boron Elevates Steel Properties," p. 65.)

The new SAE document, "Boron Steels in Commercial Heats" is a summary of work by 15 company participants, administered by the Subcommittee on Special Addition Agent Steels of the SAE W.E.B. Iron & Steel Committee. R. B. Schenck, Buick Motor Division, GMC, chairmanned the group.

This report is available from the SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.

Technigrams. . .

NONDESTRUCTIVE TESTS: A newly-activated group in the SAE Iron & Steel Technical Committee will investigate nondestructive testing of ferrous castings, forgings, and nonferrous materials. Specialized subcommittees will study current practices with such techniques as magnetic testing, radiography, ultrasonic tests, and magnetic particle inspection. End product hoped for in this work is a series of recommended test procedures.

POWER TAKE-OFFS: A new dimensional standard for a heavy-duty power take-off aperture is in the making in the SAE Subcommittee on Auxiliary Equipment for Trucks and Buses. The new standard will provide for an eight-bolt mounting; current SAE power take-off standard has six bolts.

COLD-DRAWN STEELS: Belief of most engineers to the contrary, torsion tests of splined shafts show less-costly cold-drawn steels may hold an advantage over heat-treated steels. But an SAE group, concerned with cold-finished steels, wants to know more about stress patterns in view of reported warping toward machined surfaces with this material. More information is being requested from Sonntag Laboratories, which conducted the splined shaft tests.

TRACTOR TIRES: A recent survey shows that new 8-ply front tractor tires, included in a recommended practice prepared by the SAE Tractor Technical Committee, are being used in the corn belt and the Middle West. One tire company distributed 3,000 of these tires to the replacement field. Although heavy wide-base rims for all of them are not yet available, they soon will be. Some complaints are coming in because new tires are being mounted on old standard rims.

HYDRAULIC FLUIDS: In its study of nonflammable hydraulic fluids for aircraft, the SAE Aircraft Wheels, Brakes, and Axles Committee has focused attention on Hydrolube U4 (a product of Navy research.) Recent investigators revealed certain shortcomings of this material. First, certain O-ring seals and micarta swell too much with Hydrolube U4. Second, it has an electrical conductivity 10 times that of water and might create serious problems.

CADMIUM PLATING: Cadmium-plated parts exposed to treated oils or greases containing organic fatty acids spell trouble, reported several members of SAE's Aircraft Engine and Propeller Standard Utility Parts Committee. Here's why: This combination strips the cadmium plating, forming cadmium soaps, which may clog oil lines and jets. It jeopardizes other parts. Committee members urged consideration of this reaction before recommending treated oils in powerplant specifications.

Youngren, Reese Named To Technical Board

HAROLD T. YOUNGREN and W. D. REESE have been appointed to membership on the SAE Technical Board, coordinating agency of all SAE technical committee

W. D. REESE

HAROLD T. YOUNGREN

work. Youngren is vice-president of engineering, Ford Motor Co. and Reese is manager of engineering, Motor Truck Division, International Harvester Co. The appointments fill vacancies on the board caused by resignation of William M. Walworth, formerly vice-president of engineering, Mack Mfg. Corp., and by the death of R.H. McCarroll, Ford Motor Co.

Study Iron's Behavior In Sub-Zero Operation

ALMOST every manufacturer of ferrous parts and equipment has his own way of making the product stand up in cold-weather service, according to replies to a questionnaire circulated by a subcommittee of the SAE Iron & Steel Technical Committee. Some ways are successful, others are not. But there seems to be no central fund of knowledge spelling out the "how" of picking the right material and designing the item to withstand low temperatures. (The committee hopes to develop such information.)

Among the more common methods recommended in questionnaire replies for obviating low-temperature failure of ferrous parts are:

1. Use of chrome nickel or high-nickel austenitic steel;

2. Aluminum-killed steels alloyed with nickel;

3. Use of low-alloy high-tensile steel for structural members to increase safety factor;

4. Redesign to eliminate stress concentrations due to welding;

5. Designs avoiding abrupt changes in cross-section and notch effects, as from threading. Full fillets also were suggested, as was

6. Securing tempered martensite in all heat-treated parts with quenching from tempering temperture.

These methods were developed from experience with a wide variety of parts in different kinds of frigid service: five-plow tractors: 650 lb of cast-iron cylinder blocks in 275-hp engines; 4000 lb of castings in 15,000-lb compressors; refrigerant coolers and condensers 8 ft in diameter and 15 ft long; 15-ton bulldozers and 300 to 2200-lb winches and hoists; and cast railroad truck frames up to 7000 lb.

Operating conditions for these products, a few of many produced by the 59 respondents, varied considerably. For example, automotive and railroad equipment manufacturers seem to be concerned with strength of materials down to -50 to -60F. Chemical container manufacturers must contend with temperatures as low as -350F.

TYPICAL TROUBLES

Some manufacturers are still looking for a formula that'll impart frigid-failure resistance into their equipment. A few ran into low-temperature failure of certain malleable castings, steel castings, and individual lots of cold-drawn Bessemer steel. In one case rivets and welds failed at -40F.

Another reported failure of cast-iron hubs and welded steel spokes on steel wheels. He builds the hubs integral with the wheel proper. In cold weather in North Canada, welded spokes in the rim loosen and the weld breaks.

A maker of motor graders advised of excessive breakage of the following parts induced by low temperature: main frames, leaf and helical springs, front idler steel castings, track links, power train gears, and bolts and capscrews.

One main frame failed at -20F, the other at subnormal temperatures. Leaf and helical springs failed largely in high-altitude low-temperature regions. Front idler castings proved to be notch-sensitive at reduced temperatures because of poor deoxidation practice and heat-treatment.

Need for performance of these wrought and cast irons in frigid-zone operation takes on added importance in the light of their growing use. Some respondents see increased use of malleable iron in automotive and war equipment, especially for Arctic operations. Chemical industries are going to ultra low-temperature processing. There's an increased demand for oxygen and low-temperature solvent processes.

Also on the rise is use of refrigeration in dewaxing and treating oils, which requires ferrous materials for low-temperature service.

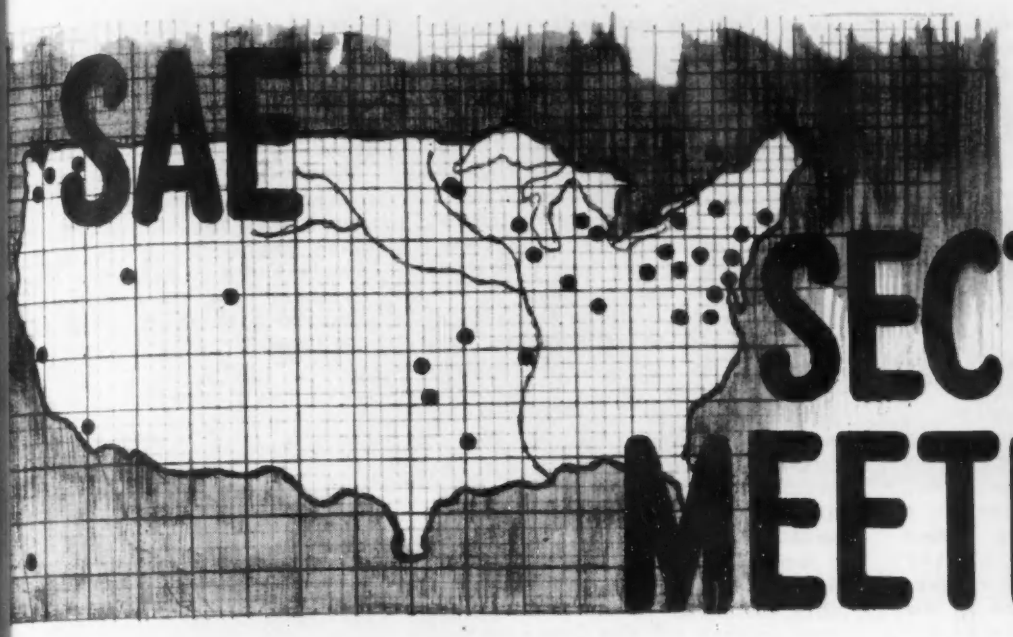
The Division on Low Temperature Properties of Ferrous Alloys, of the SAE Iron & Steel Technical Committee, is studying all replies. It hopes to evolve a recommended practice covering physical and chemical properties of ferrous materials, methods of manufacture, and heat-treatment to help the designer select the proper material for the job. Chairman C. L. Lorig, Battelle Memorial Institute, summarized replies to the questionnaire.

Release Design Guide On Helicopter Rotors

A newly-issued report on helicopter load conditions gives the engineer a basis for analyzing rotors structurally. It defines essential load conditions he must calculate to design the rotor.

So that the rotor will withstand all conceivable stresses

CONTINUED ON PAGE 85



SAE SECTION MEETINGS

SAE President Pigott is continuing his tour of Sections. At the WILLIAMSPORT GROUP'S April 5 meeting, the BUFFALO SECTION'S April 27 meeting, and the SYRACUSE SECTION'S April 21 meeting, he told members that, although our supply of crude will not last forever, it is not so low that we should start processing oil shale.

Instead, he advocated saving fuel by improving efficiency of engines and transmissions.

It was Family Night at Syracuse, and a number of guests attended. President Pigott presented a certificate of Student Enrollment to Margaret Hastings, the WAC who was marooned at "Shangri La," New Guinea. She is now an SAE student member at Syracuse University.

John L. Burns of Aircooled Motors, Inc. also received an SAE pin as a Syracuse Section award for his contributions to the automotive industry.

At the March 10 meeting of the CENTRAL ILLINOIS SECTION, Pigott presented his paper "The Supercharger and the Engine", showing how supercharged engine performance can be predicted.

Members of the WASHINGTON SECTION toured the major overhaul shops of the Capital Transit Co. on the afternoon of April 6 and learned from Hy Feldman how each shop fits into the preventive maintenance picture.

In the evening, Pigott spoke briefly on the petroleum situation and E. D. Merrill, E. C. Giddings, and A. E. Savage, all of Capital Transit, discussed the company's research and development program.

As an experiment, Washington Section is running a five-session course on instruments for diagnosing engine ailments.

Four Section meetings last month focused on automatic transmissions. To COLORADO GROUP and CHICAGO SECTION, Oliver K. Kelley pointed out that the big reason for developing the new transmissions is to remove the work of gear shifting and clutch pushing from driving.

He predicted that a new era of drive design will open in the next 10 or 25 years.

In answer to questions on lubrication requirements of the torque converter, Kelley said at Chicago meeting on April 13, that the thinnest oil, with high oxidation resistance and high aniline point, is desirable, but that thin oils may leak at seals.

He felt that SAE 10 oil with good oxidation resistance should be satisfactory.

The Colorado meeting, held March 22, was a joint SAE-ASME meeting.

Carl A. Lindblom, originator of the White Motor Co.'s Hydrotorque, addressed the Colorado Group together with the University of Colorado Student Branch on April 12 and the SOUTHERN CALIFORNIA SECTION on April 19.

After detailing the features and functioning of the Hydrotorque, Lindblom predicted that hydraulic torque converters may supplement gas turbine powerplants someday in trucks and coaches.

When Southern California members asked how automatic shifting is actuated, Lindblom replied that both carburetor and ignition systems were used.

Further discussion brought out that ordinary transmission lubricants are being used and that atmospheric changes do not require oil changes.

Southern California Section joined ASTM and ASME groups on March 18 to hear J. Frank Duryea relate the difficulties of getting his third Duryea in condition for the fiftieth anniversary of the Chicago-Evanston horseless carriage race.

Principal speaker was ASTM President T. A. Boyd, who outlined the history of industrial research, proving that it pays off.

H.G. Conway's talk on "European Landing Gear and Hydraulics Developments" drew nearly 200 to Southern California's April 1 meeting. Conway, a director of British Messier, introduced Rene Lucien, leading French designer.

Claude Brosterhous of Northrop showed movies of his company's supersonic sled traveling 1025 mph.

On April 19, DETROIT SECTION members learned why curved glass - used now for rear lights and predicted for windshields - is expensive. Robert A. Miller, Pittsburgh Plate Glass Co., explained how laminations are powdered to keep them from sticking together and then bent at 1200-1500 F.

More than 200 MILWAUKEE SECTION

members turned out to hear about and see current motorcycle engines. William J. Harley of Harley-Davidson Motorcycle Co. pointed out engine features designed to give light weight, power, and flash.

He assured sceptics that motorcycle engines can be muffled.

Charles Kottcamp, Bituminous Coal Research, Inc., described the new coal-burning gas turbine locomotives to BUFFALO SECTION on March 25.

He revealed that most of the 150-ft length of the two 4000-hp locomotives under construction is taken up with coal-handling and processing equipment.

Coal is dried and crushed, transferred by a hopper to a pressure system, then blown through an atomizing nozzle against a tungsten carbide target.

After it has been burned in the combustion chamber, ash is separated in a battery of 270 3-in diameter cyclone chambers.

In spite of a near cloudburst, PITTSBURGH SECTION members and guests flocked to the April 27 dinner honoring George M. Lange of Ex-Cell-O Corp. Afterwards, Lange presented his paper "Fuel Injection for Automotive Spark-Ignition Engines."

MIDCONTINENT SECTION reviewed fleet-cost-record and carburetor-maintenance practices. L. L. Pernot, Four Wheel Drive Auto Co., advised fleet operators to compare cost items between fleets for clues to reducing expense.

Cost records also indicate competent drivers and suitable equipment, he said.

A. C. Redden, Carter Carburetor Corp., reminded maintenance engineers that service information and parts are so complete and precise that no further engineering is needed.

The carburetor should not be modified to correct malfunctioning of other parts of the engine, he said.

About 70 members of the Student Branch at Oklahoma A & M attended this meeting. Earlier they had been guests of the Continental Oil Co. for luncheon and a tour of the Ponca City refinery.

SPOKANE-INTERMOUNTAIN SECTION took Washington State College Student Branch on a tour of automotive plants in Spokane on April 30 and May 1.

Invited also to the section meeting April 30, the students heard Maj. Edsel L. Lyon, Maj. George F. Owne, and Lt. Alfred W. Mullan of the Spokane Air Force Base describe all-weather flying aides.

Some 300 CANADIAN SECTION members and guests attended the annual Windsor dinner meeting and heard Melvin E. Estey, Perfect Circle Corp., give his paper "Cylinder Wear and Distortion as Measured with the Cylinder Contour Gage."

● SAE members Charlie McIntyre, left, and Dan Kelly with Roy Peterson of Toledo Technical Council in one of the conferences which made the joint SAE-TTC meeting March 29 such a success

● Past-President Art Scaife, left, meeting speaker Carl A. Lindblom, and Chairman J. C. Gill discuss torque converters and hydraulic drives with some of the 350 Southern California members who attended the Los Angeles meeting April 19

● Southern California claims the distinction of holding the first Governing Board meeting held on the high seas. Board members and crew are shown on the deck of Tom Collins' 110-ft yacht "Pamatomige" on March 20

● Washington Section members watch steam cleaning process in bus maintenance shop of Capital Transit Co. before April 6 meeting

● At the Detroit Section's April 5 Student Meeting, Wilbur Shaw, left, Norman Olson, Tommy Milton, Lee Oldfield, and Chet Ricker recall their racing experiences. That's Chairman Bob Insley behind Shaw

● Hyman Feldman, left, E. L. Merrill, Hoy Stevens, President Pigott, S. E. Emmons and A. E. Savage at the Washington Section Meeting April 6

SAE Section Chairmen

BRYANT
. . . . of Milwaukee

E. E. Bryant was one of the founders of Nelson Muffler Corp., in 1939, after 15 years of important project work with Burgess Battery Co., where he worked on straight-through-type mufflers, air cleaners and silencers, and other air conditioning and silencing equipment. With Nelson, as director, treasurer, and vice-president, he has been designing and developing mufflers for all types of industrial engines, and carrying on a study of quieting light aircraft.

He has been on Milwaukee Section's Governing Board since 1941, and now serves on the National Student Committee and Diesel Engine Activity Committee. He carries on, too, a long list of other activities, including scouting and Lions Clubs.

Hunting leads the list of hobbies, followed closely by fishing, boating and golf in summer, skating, ice boating and skiing in winter.

-by Ralph Switzer

Here are three more biographies of 1947-48 Section Chairmen

BONHAM
. . . . of Southern California

L. D. Bonham had a hand in establishing a still-unbroken world altitude record of 72,395 ft for stratosphere balloons. That was back in 1934-35, right after he graduated from University of Cincinnati, when he worked on the balloon project sponsored by the National Geographic Society and the U. S. Army Air Corps.

He took his talent to commercial aircraft enterprise in 1936, when he became project engineer on Lockheed's XC-35 - the first pressurized aircraft to fly the substratosphere.

Fletcher Aircraft Corp. now has the benefit of his services as assistant to the chief engineer; with the combination of "Bonnie's" presence and industry rumors of Fletcher's impending design release to the Air Force, another chapter of aircraft achievement will probably be recorded in the near future.

Just mention hunting or fishing and Bonnie is right in there pitching the tall tales with the rest of the boys. He likes the outdoors and needs only a moment's notice to have all his camping gear ready for a trip. He returned from a recent trip to Monument Valley loaded with conchas, kachinas, jewelry, and other pieces of Indian art, plus rocks of all colors, shapes, and sizes to add to his collection in the cactus garden.

-by R. V. Lindberg

HOLLERITH
. . . . of Baltimore

Curiosity is one of Herman Hollerith Jr.'s many virtues... It taught him what makes ships, airplanes, trucks, and even radios tick. He's also contributed a new thing or two to these fields.

After being graduated from Worcester Polytech in 1917, (where he burned midnight oil with SAE General Manager John A. C. Warner), Herman surveyed the shipbuilding business from a helper's vantage point with the Newport News Shipbuilding and Drydock Co. He then took Horace Greeley at his word and went West with the White Motor Co.'s experimental department to learn about truck engines.

New-fangled flying machines lured him to the Naval Aircraft Factory in Philadelphia, during World War I, where he formed one-fourth of the factory's first experimental department. There Hollerith designed the first aerial-torpedo release gear, and participated in initial tests of the aerial torpedo invented by the late Admiral Fisk.

After the war, he joined Victor Talking Machine Co. to find out about home radio and stayed to serve as Chief Production Engineer and Chief Engineer. In the early thirties he helped organize a mechanical development group to engineer special projects. One of these was an underseas movie camera.

In 1939 his latent leaning

toward aircraft took him back to that business, this time with Glenn L. Martin, for work on the Martin Mars. Herman joined Martin's Material Control Group, which handled material substitution problems and assisted in the synthetic rubber program. He now heads this group, responsible for all materials specifications.

Since 1918 he has been an active SAE member. Just a few of his jobs were: Meetings Committee Chairman (1919-1920), Secretary (1920-1921), and Chairman (1921-1922) of the SAE Pennsylvania Section (now Philadelphia Section); and Vice-Chairman for Aeronautics (1945-1946) for the Baltimore Section. He also devotes time to ASME activities.

Two of his three daughters and his son are chips off the old block, having technical inclinations of their own. Sally was a weight engineer at Martin until her recent marriage; Lucia works in the photographic lab at Johns Hopkins Hospital; Herman III, who served with the Air Corps Engineers in New Guinea during the war, shares his father's enthusiasm for boating and tinkers in his dad's home machine shop.

Technical Committee Progress

CONTINUED FROM PAGE 80

imposed on it, the report prescribes load factors for various ground, flight, and fatigue conditions.

Under ground conditions, the report suggests that the rotor at rest should be capable of taking one and one-half times the maximum torque. The load should be distributed equally between both blades of a 2-bladed rotor; between two blades of a 3-bladed rotor; and between three blades of a 4-bladed rotor – provided such rotors have vertical lag or drag hinge.

Maneuver-condition load factors cover powered and autorotative forward flight. For sudden roll or yaw, use of vertical load factor of 2 is specified. In calculating for gust conditions, the designer is told to assume that a 30-fps pressure acts on the rotor.

Another set of design computations the helicopter engineer must make, according to the report, concerns fatigue conditions. He must find effect on stresses in plane of flapping and in plane of rotation.

For hinged blades, the engineer is instructed to increase the fluctuating-stress range 50% in either direction, unless strain-gage or other exact data shows this to be unnecessary.

Rigidly-held or tetering blades might introduce fatigue stresses of short duration but critical intensity in maneuvers such as jump take-off or pull-up. Fatigue investigation for these blades should be extended accordingly, says the report. Both magnitude and duration of fluctuating stresses should be taken into account.

The designer also may make optional calculations for loads in flat turns, spiral dives, and sudden stops in forward and lateral flight.

SAE Aeronautical Information Report No. 21, The Definition of Essential Load Conditions for the Helicopter, was prepared by the SAE Helicopter Committee, headed by R. H. Prewitt, Prewitt Aircraft Corp. It's available from SAE Aeronautics Department. Price: 50¢.

18 Aero Standards And Reports Issued

FIFTEEN new and revised SAE aeronautical standards, two aeronautical recommended practices, and an aeronautical information report were just published. They are:

1. AS 41B, Propeller Shaft Ends - Single Rotation;

2. AS 91A, Propeller Shaft Ends - Dual Rotation (Propeller-Supplied Bearings);

3. AS 196, Thermo-Sensitive Element (Iron-Constantan). This is a dimensional standard on construction of the unit.

4. AS 198, Wheel and Axle Dimensions, Low-Pressure Stub-Axle Type;

5. AS 199, Wheel and Axle Dimensions, Low-Pressure Straight-Axle Type;

6. AS 213, Cranking Motor - 12v. Specified here are the minimum general and environmental requirements, performance, and qualification tests of cranking motors which engage with a gear in the engine.

7. AS 214, Generators - 12v. This standard outlines the same kind of requirements for engine-driven generators as are given for cranking motors in AS 213.

8. AS 215, Generator Control Unit - 12v;

9. AS 216, Magnetic Switches - 12v;

10. AS 221, Gasket - Two-Bolt Exhaust Flange;

11. AS 222, Flange - Two-Bolt Exhaust;

12. AS 223, Flange Installation - Two-Bolt Exhaust;

13. AS 234, Thermo-Sensitive Element (Resistance Bulb Type);

14. AS 235, Terminal Thermo-Sensitive Element;

15. AS 236, Adapter, Thermo-Sensitive, Element.

16. ARP 147A, Nomenclature, Aircraft Air Conditioning Equipment. Included in this recommended practice are the definitions of 117 terms, beginning with "adiabatic discharge temperature" and ending with "Y factor."

17. ARP 175, Temperature Measurement, Well Insert Type. This covers the temperature-response characteristics of various temperature-response elements for well-type installation in air-cooled aircraft engine cylinder heads.

18. AIR 17, Structural Characteristics of Aircraft Tubing. This aeronautical information report contains physical properties and sectional characteristics of round, oval, and streamline tubing. Also given are formulas for finding dimensions of streamline and oval tubing.

These 18 standards and reports,

all of which were published recently for the first time - with the exception of the three with suffix letters, are available from the SAE Aeronautics Department.

LUBRICANTS

CONTINUED FROM PAGE 69

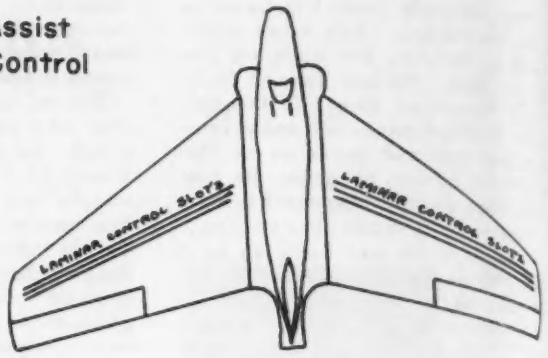
combination of extreme pressure materials and compounds to increase oiliness which must pass rigid qualification tests. It is used on bevel, hypoid, and worm gears.

Development of an all-purpose automotive grease is somewhat more difficult, because of the conflicting requirements of wheel bearings, chassis points, generator and water pump bearings, and universal joints.

With certain qualifications, such greases are now generally available.

Filled greases are becoming more popular because they are able to eliminate shackle bar bronzing, reduce bearing wear, and assure squeak-free performance. (Paper "Modern Trends in Automotive Lubricants" was presented at SAE Northern California Section, Dec. 9, 1947.)

Turbojet Engines Assist Boundary-Layer Control



● Fig. 1 - Slots for boundary-layer control

Based on a paper By

L. E. SHEDENHELM and HOPE BIGGERS

CAA Aeronautical Center, Oklahoma City, Okla.

TURBOJET and turbopropjet engines may help to keep boundary layers thinner, and so improve plane performance and reduce structural heat. The new powerplants consume so much more air than conventional engines that they provide the tremendous air volume needed for boundary-layer control. The boundary layer is a thin layer of air retarded by the friction near the surface of the wing. (A jet engine uses 100-150 tons of air per hr as compared with 1 ton for the 2000-3000-hp conventional engine.)

Both suction and pressure methods of keeping this boundary layer as thin as possible require large volumes of air. With the suction method, large quantities of air are abstracted from the boundary layer through slots in the wing. In the other method, air is ejected under pressure from the slots into the boundary layer itself.

In actual practice, the former method, that using suction, has proved more promising, for it means low power requirements for pumping, insensitivity to slot shape, and decreased pressure and volumetric coefficients.

Fig. 1 shows the use of slots to effect this control in the triangular wing configuration. For instance, effective control on a high-speed, laminar-flow section has been obtained through a series of slots located at the 45 and 75% chord points on the wing section. A promising arrangement is the use of retractible slot covers, enabling the pilot to close the forward slot for high speed flight and open it during the landing approach. When flaps are used, large gains are indicated by location of the slot on the flap rather than on the wing. It may be arranged so that the slot is sealed when the flap is extended for landing. There is some indication that slot openings of 1/32 in. are within the practical range of present wing chords.

Under icing conditions, there is also the possibility that the air drawn through the slot can be heated by drawing it over the tail cone, thus providing heat for antiicing of the aircraft

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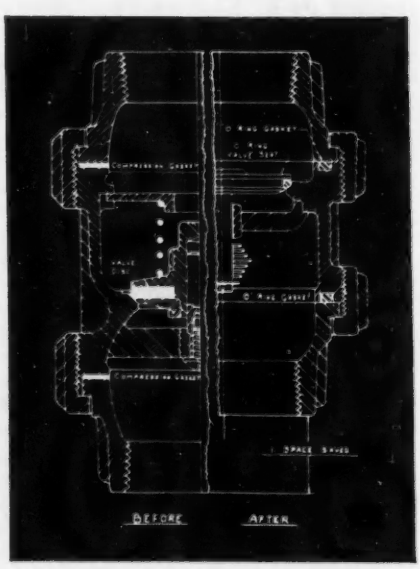
Look at the improved design made possible by using "O" Ring Seals in this double union vertical check valve made by THE OPW CORPORATION of Cincinnati, Ohio—for gasoline, benzol, fuel oil and other fluids.

Compression gaskets and a synthetic rubber valve disc were used in the original design shown at the left. By using "O" Rings the unions are screwed down only finger tight to prevent leakage. An "O" Ring is stretched over the valve disc to make a tight seal under all conditions. These changes shortened the valve 1 inch, eliminated several parts, simplified the others, reduced costs and weight, and improved the flow characteristics.

This is an example of how your problem could be solved by using "O" Ring designs. For complete Engineering Data write for our "O" RING HANDBOOK.



PLASTIC and RUBBER Products, Inc.

3110 Oakridge Drive, Dayton 7, Ohio

structure. (Paper "Notes on Turbopropjet Developments" was presented at a meeting of the Midcontinent Section of the SAE, Oklahoma City, Okla., Dec. 5, 1947. This paper is available in full from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Diesel Fuel Problems Under CRC Scrutiny

Based on paper By

W. G. AINSLEY

Sinclair Refining Co.

W. J. CARATHAUS

Deep Rock Oil Co.

and C. M. RIDGEWAY

The Pure Oil Co.

FIVE diesel fuel problems currently confronting the engine builder, operator, and oil refiner are under attack by the Coordinating Research Council's Diesel Fuels Division. They are:

1. Lower cetane fuels anticipated;
2. Sulfur effects;
3. Ignition quality measurement;
4. Smoke measurement;
5. Gum formation.

First job stems from findings of the Performance Characteristics Group that increasing demand for diesel fuels will limit availability of high cetane fuels. For this reason refiners predict lower cetane products. Greatest quantity of diesel fuels, they say, will approximate No. 2 and No. 3 domestic heating oils and will tend to become lower in cetane number.

This group is exploring fuel types representing minimum expectations to get down to marginal fuel that might be needed to augment the supply. Full-scale test work will be conducted by representatives from engine manufacturers, fuel suppliers, and the railroads—who are particularly concerned.

Growing attention to fuel sulfur content as a promoter of engine wear and deposits prompted another group, Effect of Sulfur on Engine Operation, to continue its program. It already has found low sulfur fuels produce less wear and a cleaner engine. Determining whether effect of sulfur is independent of source or processing method is the present objective.

The group concentrating on problem No. 3 is searching for a method more adequate than the F-5 procedure for measuring ignition quality. For example, predicting starting ability by the F-5 procedure is less than satisfactory for diesel fuels containing chemical additives. Many such chemical compounds produced fuels of improved cetane number as measured by the F-5 procedure; but they failed to improve the fuel's ignition ability under cold starting conditions.

Fourth project concerns itself with improvement of the CRC Photovolt Smokemeter. A survey of participants in this work shows the device still has a few minor bugs to iron out. This group also will assist the SAE Smoke Committee by digging up data to show correlation between CRC Smokemeter and Ringleman Chart results.

Last of the diesel fuel problems being probed is the formation of gum. Laboratory procedures for predicting amount of gum in fuels are being finalized. Specialists on this job are looking for more actual service information in the form of samples of fuels that caused engine trouble because of gum. (Paper "Progress Report on the CRC Diesel Fuel Program," was presented at SAE National Fuels & Lubricants Meeting, Tulsa, Nov. 6, 1947.)

About SAE Members

CONTINUED FROM PAGE 73

LaMOTTE T. COHU resigned the presidency of Trans World Airline a year after succeeding JACK FRYE to become an executive of Consolidated Vultee Aircraft Corp.

Recently affiliated with the Standard Oil Co. of Calif., Aberdeen, Wash., O. T. FINNEY is now fuels and lubricants engineer with this company in Anchorage, Alaska.

Now staff research engineer for Research and Development Division, School of Mines, Albuquerque, N.M., BRUCE EDWARD HOVERSON had been employed as engineer, in the Research Division of Fairbanks-Morse & Co., Beloit, Wis.

Having left the Tropical Oil Co., Bogota, Colombia, South America, J. W. LEACH is now

Silicone News

DC SILICONES

Silicones Save Cylinder Heads from Corrosion

Cylinders of new Harley-Davidson '2-Cycle' motorcycle protected from rust by modified silicone coating formulated by Midland Industrial Finishes Co.

PHOTO COURTESY HARLEY-DAVIDSON MOTOR CO.

Rusting of metals exposed to high temperatures and moisture was once as certain as taxes. That was before silicones were introduced by Dow Corning Corporation. In all of their various forms, these organo-silicon oxide polymers are indifferent to extreme heat or cold—and they repel water.

That's why the Harley-Davidson Motor Company of Milwaukee, Wisconsin, tested and then finally specified a modified silicone coating formulated of Dow Corning Silicone Resins for the cylinders of their new Model 125 motorcycles. Preliminary tests showed that the Modified Silicone Aluminum Coating made by Midland Industrial Finishes Company of Waukegan, Illinois, maintained its film continuity even after being exposed to 1000°F. and plunged into water, 70°F. Immersion in water for 24 hours resulted in no appreciable softening, blistering, rusting or discoloration of the coating.

The coating was then applied to the cylinders and exhaust pipes of a 1948 Big Twin motorcycle, and the motorcycle was driven 1,893 miles. The cylinders retained their original new appearance with the exception of slight oil burns. The coating was tough and resistant to scratching. It did not soften when cleaned with gasoline or naphtha.

This is only one of the many applications in which DC Silicone Resins help to prevent rusting of hot metal surfaces. These silicone resins are described in Data Sheet No. D 8-2.

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New York • Chicago • Cleveland • Los Angeles
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Dow Corning
FIRST AID SILICONES

field engineer of the Technical Service Division of Imperial Oil, Ltd., Sarnia, Ont., Can.

JOSEPH P. McGRATH recently became assistant plant engineer with the U. S. Gypsum Co., Inc., of Jersey City, N. J.

NATHANIEL S. PRIME is now assistant technical director, Technical Department, Biological Division, Chemical Corps, U. S. Army, Frederick, Md.

GERALD H. SMITH recently became an engineering draftsman with North American Aviation, Inc. in Inglewood, Calif.

EVERT C. HOKANSON is now assistant manager of the Pacific Coast Office of the Whiting Corp., located in Los Angeles. He had been with this company in Harvey, Ill.

Heretofore connected with the Pure Oil Co. in Chicago, MARTIN B. CHITTICK has become technical director and director of technical sales for the American Mineral Spirits Co. in New York City.

SMITH BOLTON, who had been secretary and sales manager of the United States Graphite Co., Division of the Wickes Corp., Saginaw, Mich., recently became vice-president and general manager of the company. FREMONT F. RUHL is now sales manager.

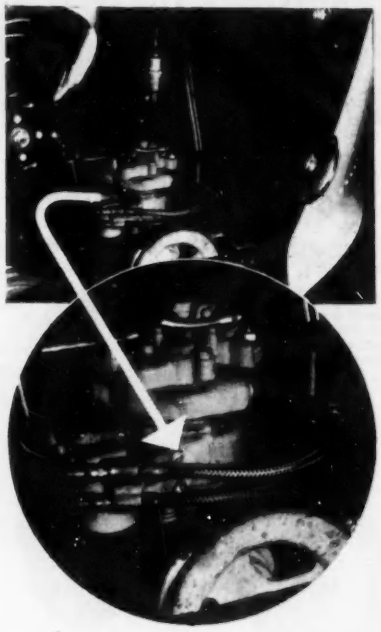
HOWARD H. KEHRL has become an engineer with General Motors Research in Detroit.

JOSEPH R. BENGOECHEA recently became natural gas engineer with the Federal Power Commission in Washington, D. C.

Heretofore with the U. S. Maritime Commission, Training Division, St. Petersburg, Fla., JACK S. GILHART is a research engineer at Babcock & Wilcox Co., Alliance, Ohio.

JOHN F. SCHMIDT has accepted the post of patent attorney with the Joy Mfg. Co. in Pittsburgh, Pa.

Recently a graduate student at Cornell University, Ithaca, N.Y., STUART HAMILTON has become analytical engineer at Pratt & Whitney Aircraft, Division of United Aircraft Corp. East Hartford, Conn.



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The two TITEFLEX lines illustrated are air lines used to operate the "shutterstat" on a Flxible coach. In addition to being air tight, these lines must be capable of withstanding both heat and cold. The all-metal construction of the TITEFLEX lines satisfies these conditions on every count.

We would like to tell you more about TITEFLEX oil, gas, hydraulic, and air lines—the lines that are specified by so many leading bus and truck manufacturers because they are made to stand up under the most severe service conditions. TITEFLEX lines seldom, if ever, need to be replaced. Write for literature, or, if you prefer, we will have our representative call.

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All-Metal Flexible Tubing

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"...Might be if you have become deadened to production headaches. Personally, I've found cutting fluids are a major factor in operating a modern metal working plant. They can make or break most jobs. And that's not hard to understand when you consider all the variables involved. Speeds, feeds, materials, tolerance and finish requirements all influence the application of a cutting fluid. Oil that is 'just oil' simply cannot give you the performance you need. Fortunately, it is a problem that can be satisfactorily solved by *qualified* cutting oil people. It's their full-time business. They have the experience plus the facilities that no individual user can match. I've learned that it pays to take advantage, not only of their tested products, but of their experience and service as well."

—Chip

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Recently graduated from Fenn College in Cleveland, Ohio, ELTON A. OVERLY has become associated with J. F. Pritchard & Co., Kansas City, Mo.

Now executive vice-president and general manager of the Waltham Watch Co. in Waltham, Mass., PAUL P. JOHNSON had been manager of the Accessories Division for Thompson Products, Inc., Cleveland, Ohio.

OBITUARIES

DR. FRANK O. CLEMENTS

Retired as director of General Motors Corp. research laboratories eight years ago, Dr. Frank O. Clements died May 8 in Columbus, Ohio, He was 73.

He had been a student instructor at Ohio State University in 1904 when he became chief chemist for the National Cash Register Co. in Dayton. In 1916 he accepted an invitation from SAE Past-President C. F. Kettering to help organize the Dayton Engineering Co., and served as its first technical director.

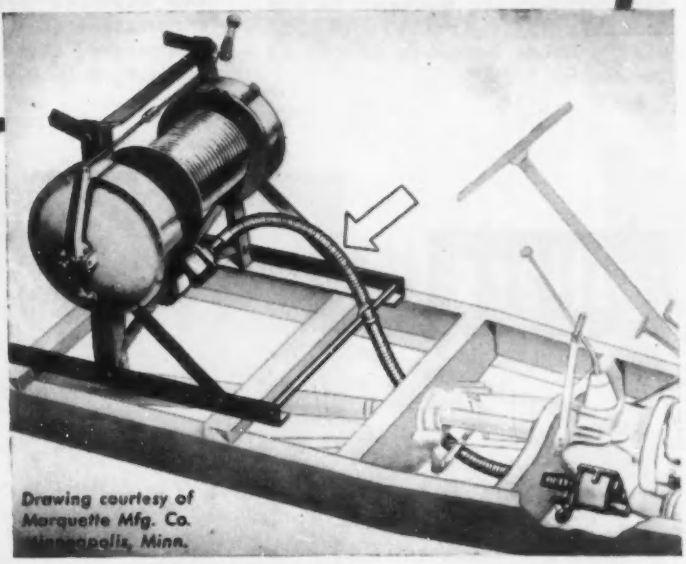
Following World War 1 when General Motors acquired Delco interests, Clements became technical director of the new Research Laboratories Division of the Corporation under Kettering.

WILLIAM S. KNUDSEN

William S. Knudsen, whose production and administrative genius took him to the presidency of General Motors Corp., died April 27 in his home in Detroit. He was 69, and had been ill for 16 months.

He was wartime head of industrial production and later a lieutenant general in charge of the Army's armament program. Knudsen entered the automotive industry a few years after arriving in New York as an immigrant from Denmark with John R. Keim Mills in Buffalo, bicycle manufacturer who began making parts for Ford Motor Co.

A GOOD WAY TO PROVIDE *Power* FOR ACCESSORIES



Drawing courtesy of Marquette Mfg. Co. Minneapolis, Minn.

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With an S.S. White flexible shaft connected to a take-off on the engine or at some other point in the transmission, you can deliver power to any point in an automobile, bus, truck or tractor.

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One of America's AAAA Industrial Enterprises

That company was merged with other Ford interests in 1911, and Knudsen soon was put in charge of the company's 27 assembly plants. During World War I he was in charge of building the fleet of Eagle boats. At war's end he became production manager of the Model T, and installed the company's three assembly plants in Europe in 1919.

He left Ford to head a Detroit metal manufacturing firm, and in 1922, joined General Motors Corp. and was soon in charge of Chevrolet production, then headed that division, and 11 years later became executive vice-president and was elected president of the corporation in 1937.

Appointed director of industrial production by President Roosevelt in 1940, he resigned his GM posts and undertook his huge task with characteristic vigor. His hard traveling schedule in this country and to and from battlefronts drained his energy and he never fully regained his vigor. He joined the SAE in 1934.

Applications Received

The applications for membership received between April 10, 1948 and May 10, 1948 are listed below.

Baltimore Section: James H. Horton.

British Columbia Group: Vernon Harper, John O. McDonald, Gilbert W. Plant, Norman Harold Wallace.

Canadian Section: Ralph Biggar, Harold B. Chambers, John L. Housley, Ronald Govan Kilgour, Arthur N. Lemon, Richard David Margesson, J.H. Sanderson, John R. Sumner, Ronald M. Thomson, John D. Vicary, Lynne Everett Windsor.

Chicago Section: John A. Bell, Renato P. Celabrese, Walter E. Gardner, George W. Grant, William E. Gribnitz, Jr., Jack E. Gutridge, Ray W. Harrow, Robert H. Lindberg, Joseph Michelini, F.L. Murphy, Franklin A. Sweger, Jr., Lloyd M. Swenson, Hubert John Thomiszer.

Cincinnati Section: Roy W. Stiegler.

Cleveland Section: Richard A. Albrecht, Troy P. Baughman, Albert George Catlin, Vahey S. Kupelian, Clifford C. Lace, John E. Martin, Irving A. Oehler, Donald H. Perry, Robert D. Prouse, Otto J. Riss, Harold L. Walters.

Dayton Section: John W. Caulder, Harry Madison Blank, Paul W. Rogers.

Detroit Section: Axel Floyd Leroy Anderson, Maxwell N. Anning, Loren E. Boysel, Ben F. Bregi, Robert Osborne Brines, John R. Craig, Jack Frederick Fralick, Jack William French, Jerry L. Gitre, John Karmazin, Jr., Gregory Kraus,

Deo Donald Lewton, Robert Haaren Maguire, A. B. Marshall, L. S. McCune, Harold A. McHale, Harlan J. Oakes, Lloyd Trent Peterson, Joseph Pizzo, Arthur M. Reibitz, Robert Lauren Wiltse.

Hawaii Section: Marcus R. Colburn, Jr., Jerry L. Cook, Robert William Munroe, Stanley H. Neser, Herman J. Pomy.

Indiana Section: Govind M. Asrani, Charles Marion Keepers, Theodore C. Nolte, LeRoy Rueter.

Mid-Continent Section: R.S. Burgin.

Milwaukee Section: Edward A. Hunt, G. R. Layden, Stanley Victor Puidokas, Clair M. Robertson.

Metropolitan Section: Jerome Bartels, Herman G. Claussen, T.R. Collioud, Thomas V. Douglas, William J. Fowler, Walter R. Hess, Martin E. Karp, Wilson S. Litzenberger, Ernest J. Lombardi, Charles C. Marcus, Max A. Morgenstern, George J. Munz, Elmer Fred Nabstedt.

Northern California Section: Chester A. Kemp, Jr.

Northwest Section: Fred W. Bond, Albert Hautenne, Arthur T. Jackson, Burnette H. Murray, George M. Shrum.

Philadelphia Section: John W. O'Hara, William Tauss.

New England Section: C. Norman Fay, Joseph Nunes, Henry M. Strout.

Oregon Section: Stanley J. Coffey, Alvan Sutton Moore.

Pittsburgh Section: Hiland G. Batcheller, Jeff Coats, Cecil A. Lediard, George P. Rosser.

St. Louis Section: Harry W. Decker.

Southern California Section: Henry L. Clark, William A. DeRidder, Berry W. Foster, Phillip Richard Heim, Charles M. Howell, William K. Knepp, Charles O'Donnell Lee, Marion Sloan McKellar, John F. Nichols.

Syracuse Section: Leon Carpenter, Theodore Boggs Dunbar.

Texas Section: G.W. Dickey, P.D. Megginson, J. J. Shore, J. D. Stewart.

Twin City Section: Herman G. Bunn, Gordon W. Johnson.

Virginia Section: Philip D. Boehm, Jr., R.W. Duffer.

Washington Section: James Denny Clark.

Wichita Section: Charles Y. Allison, Jr., LeRoy B. Clay, J.C. Wilson Jr.

Outside of Section Territory:

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Foreign: Tore Berg, Sweden; Kenneth Brooks, England; J.J.W. denHaan, Holland; Guillermo Gonzalez Gomez, Central America; Ernest John Newton, England; Russell Clarence Bertram Reeve, New Zealand; Frederick Owen Walter, England; Patrocle John Yangos, South Africa.

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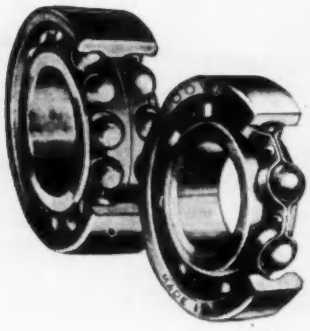
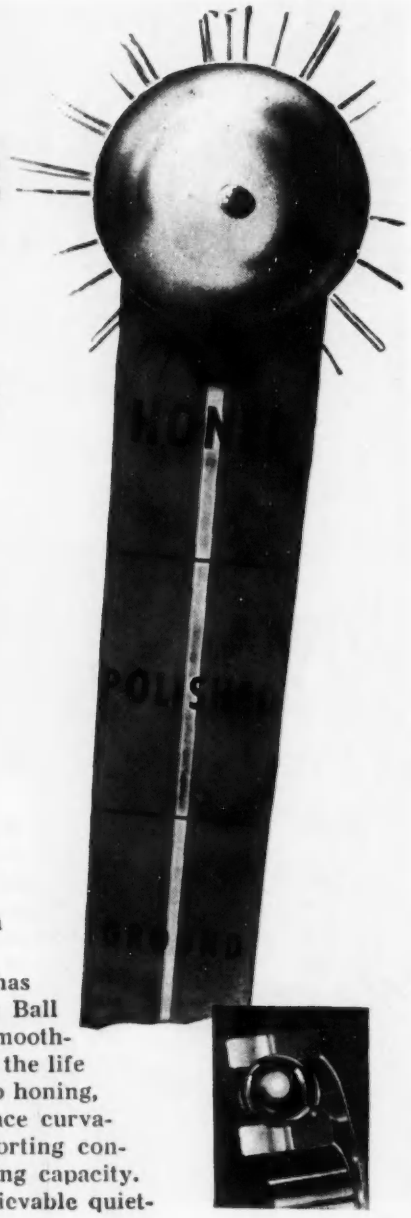
30% greater load capacity





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New Members Qualified

These applicants qualified for admission to the Society between April 10, 1948 and May 10, 1948. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

British Columbia Group: H.A. Burnett (A), Frederick Phillip Holmes (A), Charles T. Stewart (A), W. H. Traeger (A).

Buffalo Section: Henry J. Falkowski (J), G. Thomas French, Jr. (M), Frank W. Person, Jr. (M), James Richard Petters (J).

Canadian Section: W. Arch Bryce (M), Robert Bruce Corneil (A), J. Charles Cusson (A), Frederick W. Davies (A), C. S. Finkle (M), Leslie Gelb (J), Alvin E. Jennings (A), Stafford Wm. McDermott (M), William John McNeely (M), Walter Marshall Smith (J), Harry P. Weston (A), John Edward Wilcox (M).

Central Illinois Section: Guy F. Morris (J), Bernard F. Vogelaar (J).

Chicago Section: Marvin W. Dundore (J), W. A. Duvall (M), Andrew G. Forest (M), H. B. Garvey (A), Charles E. Krupp (A), Albert E. Mansfield, Jr. (A), Robert O. Smith (A), Paul K. Tchang (J).

Cincinnati Section: Fred W. Dries (A), Frank W. Gueterman (A), E. H. Malden (A), William Gilbert Meyers (A), P. Lee Myers (A), Fred E. Nichols (M), Edward E. Strike (A).

Cleveland Section: Peter L. Gitter (J), David L. Raymond (J), Edward Wilson Paul Smith (J), William Swallow (M), Paul C. Taylor (M), Stanford Washkewicz (J), George W. Wolff (A).

Colorado Group: Harold G. Davidson, Jr. (A), Frank L. Ficca (A), Don Giacomozzi (A).

Dayton Section: Paul C. Hanlon (SM).

Detroit Section: Wm. L. Bartholomew (A), Robert J. Belz (M), Robert LaVern Black (J), John R. Buckles (J), Darnall Burks (M), Roland H. Burks (M), Charles Fales Cooper (J), Robert Lee Dolan (J), Richard E. Drew (J), Gustave Elko (M), Carl H. Exselsen (J), Elbert Edgar Haight (M), Robert S. Harmount (M), Edward J. Herbenar (A), Willard Robert Houser (M), Volney F. Landry (M), John Maguire (M), Edward H. Miller, Jr. (A), Ray J. Miller (M), Robert D. Morrison (J), Earl V. Olgren (J), Von D. Polhemus (M), Richard Donald Purcell (FM), R. W. Rockefeller (M), Joseph R. Roda (FM), Stanley D. Sagan (J), Jules F. Saut (J), Louis A. Selin (A), Wilbur J. Sherrin (M), Richard Harry Simpson (J), Marion L. Smitley (M), Holger S. Smitt (J), Robert F. Thomson (M), Clifford C. Whiteford (A), Arthur H. Zeitz, Jr. (J).

Hawaii Section: Gilbert Hay, Jr. (A), Stanley O. Hornbuckle (A), Michael Nicko (J).

Indiana Section: Vern C. Vanderbilt, Jr. (J).

Kansas City Section: James R. Cannon (J), Kenneth J. Holloway (J).

Metropolitan Section: Howard Joseph Graninger (J), Thomas M. Mohoney (A), Mortimer A. Maurer (A), William A. Mehl (A), Louis F. Muller, Jr. (J), Walther Prokosch (M), John H. Walsh (A).

Mid-Continent Section: Walter H. Esser (M).

Milwaukee Section: Harry C. Eckles (J), Walter Carl Kroening (A), Edmund J. Pobar (M).

Mohawk-Hudson Group: Walter L. Glass, Jr. (A).

New England Section: Walter Odro Cralle, Jr. (J), Wallace L. Lindquist (A), James Crockard Osborne (FM).

Northern California Section: Rutter Armey (A), Clyde Sitton (A).

Northwest Section: Robert Leonard Couture (A), Charles E. Heniken (A), Norman Sarchin (J).

Oregon Section: E. V. Seshadri (J), Glenn E. Stevenson (A).

Philadelphia Section: Fred Hague (M), Theodore A. Kramer (M), Raymond Hunter Perry, Jr. (J), T. P. Simpson (M), John F. Socolofsky (J), Frank Elmer Urban (A), Lawrence D. Vogt (J), Warren T. Zivie (J).

Pittsburgh Section: Herman Muster (A), William V. Spurlin (M).

St. Louis Section: Paul B. Hartzke (A), Julian G. Ryan (M), Herbert K. Sachs (J), Kwang-yeh Tao (M).

San Diego Section: Edwin David Hayward (J).

Southern California Section: Nicholas Bashark (M), Thomas Clifford Jenkins (M), Ray Lawrence (A), Harold B. Marlowe (A) Rudi

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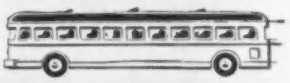
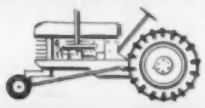
Trucks and Trailers



Busses and Trackless Trolleys

Industrial Electric Trucks



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Southern New England Section: James Nassau (J), Donald D. Pascal (J), William Rose (M), George B. Wood (M).

Syracuse Section: John Leo Burns (M), Kenneth Digney (M), William Ingram Marble (J).

Texas Section: Earl W. Davis (A), Olin F. Tawwater (A), Francis B. Voltz (M).

Virginia Section: Channing W. Daniel, Jr. (J).

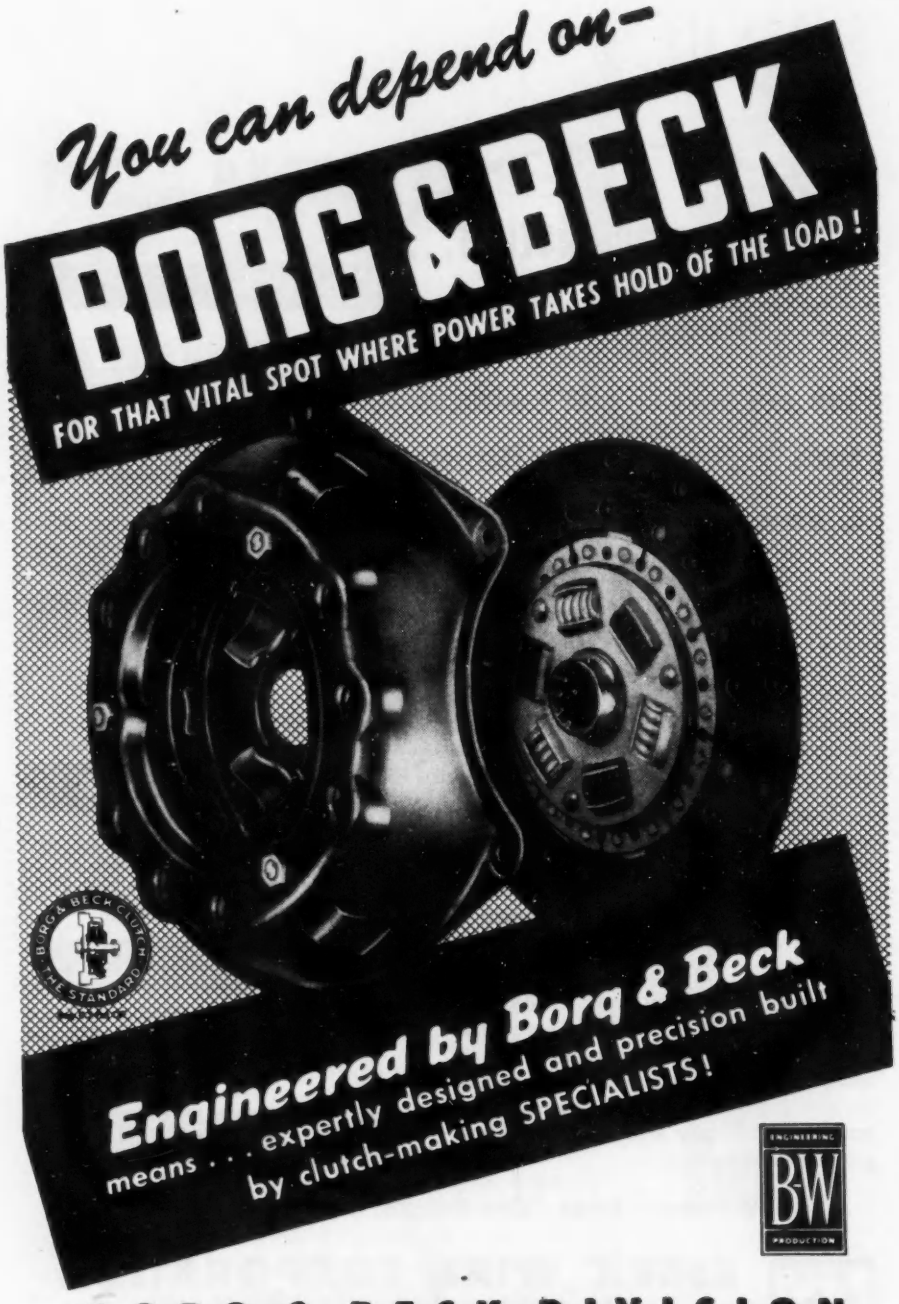
Washington Section: Albert B. Cason, Jr. (J), Robert F. Harvey (SM), James H. Lamb (A), Benjamin M. McKelway, Jr. (J).

Western Michigan Section: William B. Jerow (A), John K. Keating, Jr. (A), Gaylord E. Smith (M), Julian J. Sykes, Jr. (J).

Wichita Section: Waldo Briggs Burnett (M), Del Roskam (A), W.E. Shelor (A).

Outside of Section Territory: James B. Carter (A), Capt. John H. Davis (SM), R.E. Flanders (A), Emil F. Jirsa (M), Alexander D. Lewis (M), Wm. H. Love (J), Lebron B. McGonagill, Jr. (J), John H. McIntyre (J), Don R. Mitchell (M), Miss Gertrude Elizabeth Parks (J), R. W. Robinson (A), Carl H. Rust (A), Raymond F. Samuelson (M), C. Hibbard Savery (M), John D. Selim (M), Charles Bernard Tauber (M), Lt. Col. Lowell R. Whitla (SM).

Foreign: Roland Bailey-McEwan (FM), So. Africa; Robert Thompson Cutler (FM), Argentina; Howard C. Daudet (FM), N. W. I.; Ronald Roxburgh Fabel (FM), England; Addis Finney (FM), Switzerland; Leonard C. Fisher (FM), Australia; N. K. Gopalan (J) England; Alan Salisbury Lamburn (FM), England; Colin Gordon MacKenzie (J), England; Edward Victor Paterson (A), England; Miss Alison E. Walker (J), England; Errol Graham Williams (FM), Australia.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2. The Secretary or Assistant

Secretary of your Section or Group at the addresses listed below:

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L. D. Bevan, Bell Aircraft Corp., P.O. Box 1, Buffalo, N. Y.

• Canadian

C. E. Phillips, Perfect Circle Co., Ltd., 175 Wicksteed Ave., Leaside, Ont., Canada.

• Central Illinois

I. E. Howard, Phillips Petroleum Co., 2520 S. Washington St., Peoria 5, Ill.

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(Miss) C. M. Hill, Room 210, 7016 Euclid Ave., Cleveland 3, Ohio.

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D. D. Bowe, Aeroproducts Division, GMC, Municipal Airport, Dayton 1, Ohio.

• Detroit

(Mrs.) S. J. Duvall, Detroit Office, SAE, 100 Farnsworth Ave., Detroit 2, Mich.

• Hawaii

J. C. McLaughlin, 525½ 18th St., US Naval Housing, Area 3, Pearl Harbor, T. H.

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H. F. Twyman, Civil Aeronautics Administration, Room 803, City Hall Building, Kansas City, Mo.

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• Milwaukee

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• New England

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• Northern California

H. R. Porter, Standard Oil Co. of Calif., 225 Bush St., San Francisco, Calif.

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- Southern New England

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W. B. Keith, S. 303 E. St., Spokane 9, Wash.

- Syracuse

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- Salt Lake

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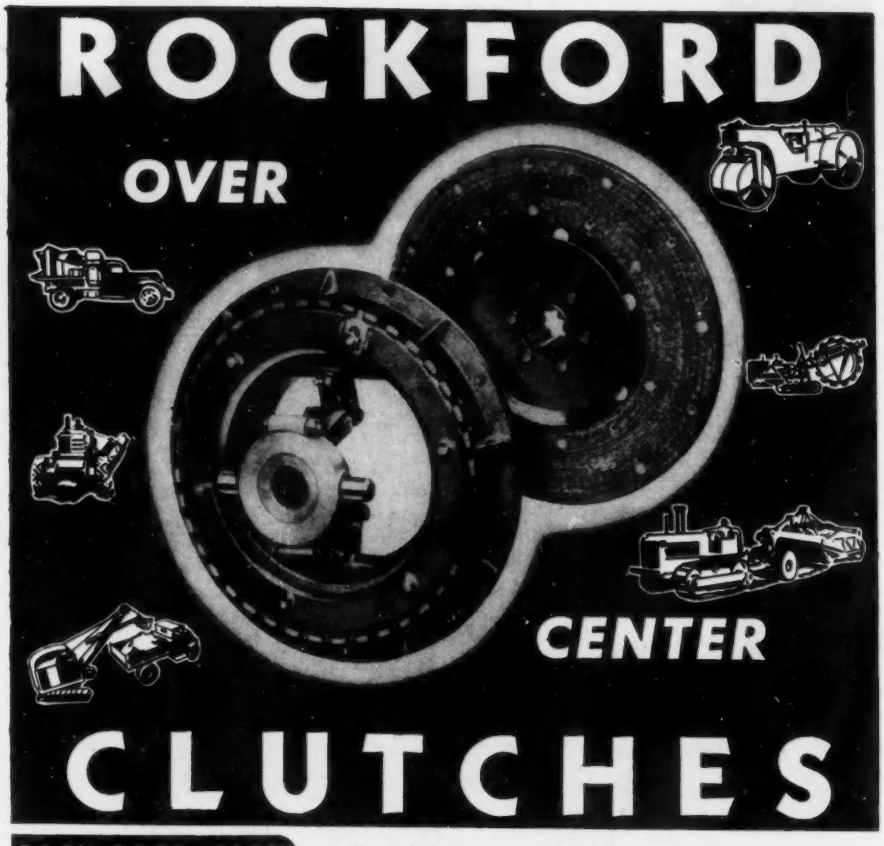
- Williamsport

R. S. Wilson, Lycoming Division, Aviation Corp., Oliver St., Williamsport 38, Pa.



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